LIPPINCOTT'S FARM MANUALS

PRODUCTIVE FARM CROPS

BY

E. G. MONTGOMERY, M.A.

"The first farmer was the first man, and all historic nobility rests on possession and use of land."

—EMERSON.

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FARM MANUALS

EDITED BY

KARY C. DAVIS, PH.D. (CORNELL)

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WHEAT, THE STAFF OF LIFE, AS GROWN IN THE GREAT PLAINS OF NEBRASKA

Page 106.

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203 ILLUSTRATIONS IN THE TEXT

"If vain our toil,
We ought to blame the culture, not the soil."
POPE—*Essay on Man*

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PREFACE

In the preparation of this book, the author has endeavored to develop the fundamental principles of crop production, as demonstrated by practical experience. In general the principles referred to are supported by experimental evidence. No exhaustive analysis of experimental evidence is attempted, but only sufficient to clearly prove the principles. Involved and debatable problems are generally avoided, as there is sufficient standard and accepted work for the scope of this book.

The text is intended for the use of students having some practical knowledge of crop production. It is hoped to meet the needs of such students in agricultural short courses, and secondary schools, and also a considerable class of beginners in agricultural colleges. Being of a practical nature, the book will also be found a handy book for farmers desiring a reference book covering all of the cultivated crops.

E. G. Montgomery.

Cornell University, Ithaca, N. Y.,
December, 1915.

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PRODUCTIVE FARM CROPS

CHAPTER I

CLASSIFICATION, ORIGIN, AND DISTRIBUTION OF FARM CROPS

Early Culture of Plants.—With the earliest recorded history of man, it appears that people at that time lived very largely upon such food plants as they could find growing wild, and whatever wild animals they could kill, even as some very primitive tribes do to-day. Wild animals were probably domesticated before the extensive culture of plants began. These could be herded on the native grasses, the people moving from place to place, as new pasture or water was required. Primitive man had no adequate tools for destroying the forests, preparing stubborn land, or cultivating crops, hence his first culture of crops began where natural difficulties were least.

These conditions seem to have been provided by the great sandy river beds and deltas in the dry regions, as the valley of the Nile or Euphrates. Here irrigation was practised from the earliest times. The culture of plants favored a settled life, rather than a nomadic life, and with settled and permanent communities, came civilization. A high civilization was first developed in these great river valleys.

No doubt the first cultivated plants were those the people were accustomed to gather as food in the wild state, as wild barley, wheat, rice, lentils and the grape. These plants have been changed and improved by culture and selection, so the present cultivated forms resemble, only in a general way, the wild prototypes. Specimens of wheat preserved from the Stone Age show the type cultivated then to be much more primitive than that cultivated to-day.

Number of Cultivated Plants.—According to DeCandolle,[1] there are among cultivated plants to-day some 46 species, out of 248, that he is reasonably sure were cultivated more than 4,000 years ago,

[1] DeCandolle, A.: Origin of Cultivated Plants (1882), pp. 436–446.

and some 60 more, over 2,000 years ago. He classifies the species as follows:

	Old World	New World
Cultivated for underground parts	26	6
Cultivated for stems and leaves	57	8
Cultivated for the flowers or their envelopes	4	0
Cultivated for their fruits	53	24
Cultivated for their seeds	58	8
Cryptogam cultivated for whole plant	0	1
	198	47

New *species* are constantly being added to the list of useful plants. Of most *species*, cultivated extensively, a great many *varieties* have been developed. For example, with cultivated wheat there are more than one thousand known varieties, and of maize or Indian corn, at least five or six hundred varieties.

Classification by Use.—Crops are very commonly classified according to use, as follows:

(1) Cereal or grain crops, as corn, wheat, oats, barley, or rice.

(2) Legumes for seed, as beans, lentils, and peas.

(3) Forage crops, as all grasses cut for hay, legumes cut for forage, sorghum and corn fodder.

(4) Roots, as beets, turnips, and carrots.

(5) Fiber crops, as cotton, flax, and hemp.

(6) Tubers, as potatoes.

(7) Sugar plants, as sugar beets and sugar cane.

(8) Stimulants, as tobacco, tea, and coffee.

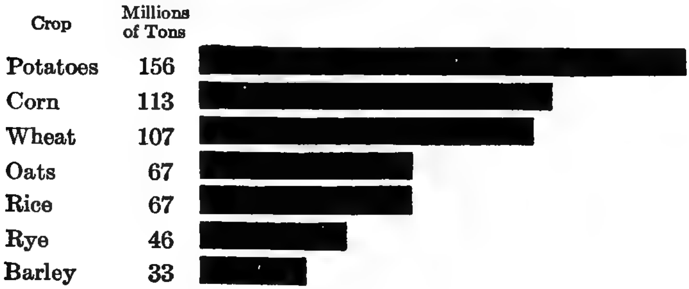
Other crops not commonly classed as field crops would be the fruits, vegetable crops, and timber crops.

Important Botanical Groups.—The most important botanical group is the grass family (*Gramineæ*) to which all cereals except buckwheat belong, and at present perhaps three-fourths of the forage crops harvested are made up of grasses. The two families next in rank are the legumes (*Leguminosæ*), so called because the seeds in most cases are borne in a pod or "legume," and the nightshade family (*Solanaceæ*), to which belong the potato and tobacco.

The Most Important Crops.—The hay and forage crop is the most valuable and extensive crop of the world, but is made up of a great many kinds of plants. The world's most important plants are

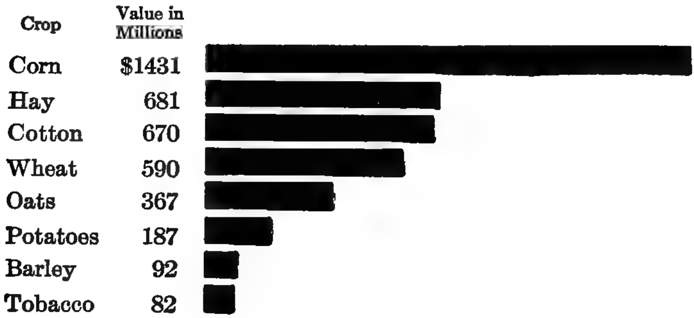
given in the following diagram, together with the yield in millions of tons:

World's Crops of the Most Important Food Plants. Average for 5 Years, 1906–1910 [2]



While the world's production of potatoes outranks all others in total yield, the wheat crop has the greatest money value, with potatoes and corn probably ranking second and third. In the United States, corn is more valuable than any other two crops, as shown by the following diagram:

Relative Farm Value of Principal Crops in the United States. Average for 5 Years, 1906–1910 [3]



Factors Affecting Culture of Crops.—While favorable weather and soil are necessary for the culture of a certain crop, yet when both of these conditions are favorable, the crop is often not cultivated. Market demands, transportation facilities, and competing crops must all be considered. For example, the southern states have

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[2] From "Corn Crops," by the author, The Macmillan Company.
[3] Ibid.

favorable conditions for producing corn, but there it can not at present compete with cotton as a cash crop. In the vicinity of great cities, as in New York State, it is the perishable and bulky products that are likely to be produced, as milk, vegetables, or hay; while at greater distance, the non-perishable and concentrated products are produced, as butter, grain and meats.

Useful References to Literature.—Statistical data will be found in the following publications, most of which may be secured free: Annual Yearbooks of United States Department of Agriculture (secure from Congressman). Thirteenth Census Report, Census Office, Washington, D. C. (available to School Libraries). Statistical Abstract of the United States, an annual publication, secured from Bureau of Statistics. Agricultural Graphics, Bul. 78, Bureau of Statistics, Washington, D. C. (small charge). Seedtime and Harvest, Bul. 85, Bureau of Statistics (small charge). A circular may be secured from any of the bureaus in Department of Agriculture or Government, giving the name and prices of publications. For History of Cultivated Plants see Origin of Cultivated Plants by DeCandolle.

QUESTIONS

1. On what kind of land did crop raising begin? Can you give reasons?
2. How did the culture of crops affect the customs of people?
3. How did cultivated plants originate?
4. Name cultivated plants belonging to each of the six groups named on page 2.
5. Can you name some important plants originating in America?
6. Name the eight important groups of cultivated plants classified by use.
7. Why is the grass family so important?
8. What are the most important crops in the world? In the United States?
9. What crops are produced near great markets? Why?
10. What crops are produced at a distance from markets?

CHAPTER II

HOW PLANTS GROW

ONLY a very general statement will be made here, outlining the important features of plant growth. The student is referred to books on botany or plant physiology for detailed information on plant growth, and text-books on soils, for information regarding the relation of soil to plants.

The Parts of a Plant.—A typical plant may be divided into three parts as follows: (1) The root system; (2) the vegetative part, consisting of stem, branches, and leaves; and (3) reproductive part, consisting of flowers, fruits, and seeds.

The general functions of the roots are to absorb water and plant food from the soil, to feed the plant. The stem and leaves have three general functions, namely: (1) To take up the solution absorbed by roots and evaporate the water, leaving the minerals in the plant for food; (2) to take in air and extract therefrom carbon for the plant, and (3) to manufacture the elements taken in from soil and air into material for growth of the plant. The reproductive organs perpetuate the plant, producing the seeds or fruits. A large share of the materials manufactured by the leaves is stored in the seeds. In the cereals, the seeds are the most valuable part of the plant.

Elements Required for Growth.—When a chemist analyzes a plant, he finds that it is composed of thirteen elements. Ten of these elements are taken from the soil as follows:

1. Nitrogen	4. Potassium	7. Iron	10. *Silicon*
2. Sulfur	5. Calcium	8. *Chlorine*	
3. Phosphorus	6. Magnesium	9. *Sodium*	

Only the first seven of the above soil elements are considered essential, but the last three, chlorine, sodium, and silicon, are always present.

From the air comes:

11. Carbon
12. Oxygen

From the water may be taken:

13. Hydrogen.

Oxygen may also come from water, and probably both hydrogen and oxygen may be taken up from soil compounds.

There are ten essential elements found in all plants. All the ten essential elements must be present or the plant will not grow. This is often tested in laboratories by growing plants in water and providing only nine of the elements, leaving out one. No matter which is left out, no growth will take place. In the case of iron, only the smallest trace is required, perhaps an ounce would be sufficient for an acre of wheat, but the plants will not grow without it.

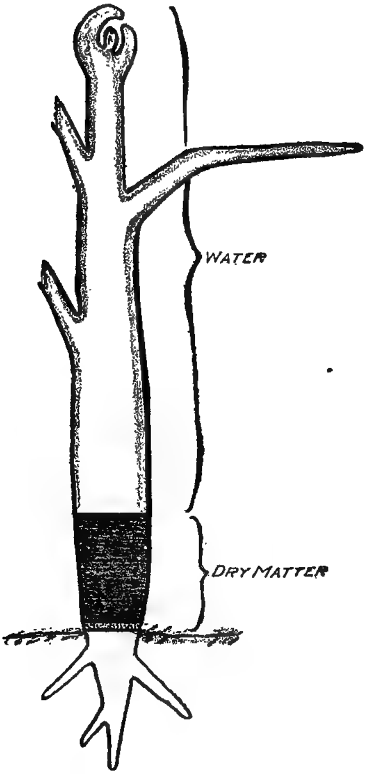

FIG. 1.—Diagram illustrating the relative proportion of dry matter and water in a green plant.

Plant Food Sources.—Most of the soil is an inert mass that plants could not live in, but throughout this mass are small quantities of the essential elements in the form of compounds. By natural decay, these compounds slowly become soluble in water, just as salt will dissolve, and then in turn, the water is taken up by plant roots, the minerals thus being carried up to the leaves.

Carbon comes entirely from the air in the form of a gas. All burning or decaying materials give up carbon dioxide gas to the air. The plant in turn is able to extract this carbon from the air, to build up new plants.

Nitrogen is taken from the soil by most plants, but all nitrogen must first come from the air. Certain bacteria living in the soil can

take up nitrogen from air, and as these bacteria die in the soil, they thus constantly leave it richer in nitrogen. Bacteria of this character are associated with legumes, as clover or peas, so that the growing of clover always leaves the land rich in nitrogen.

Thus, four of the important elements of plants come from the air—oxygen, hydrogen, nitrogen, and carbon—and six from the soil. (Nitrogen, however, is first combined in the soil.)

Relative Composition of Plants.—If 100 pounds of green corn plants or grass be thoroughly dried, about 80 pounds of weight will be lost, and only 20 pounds of *dry matter* (Fig. 1) remain. Air-dry seeds or hay contain from 10 to 15 per cent water.

If the dry matter is now thoroughly burned, there will be left about one pound of ash. The 19 pounds that went up in the fire represent what came from air, while the one pound of ash is all that came from the soil. The ash represents about one per cent of green plants or four per cent of dry matter.

HOW ROOTS AND LEAVES PERFORM THEIR FUNCTIONS

The Root System.—The functions of roots are to secure water and plant food elements from the soil, acting also as an anchor. The root system is usually much more extensive than commonly supposed. With wheat or oats, roots penetrate two to four feet deep, being deeper on well-drained, porous soils than on compact or wet soil. The lateral spread is usually greater than the depth, especially with intertilled crops, as corn or potatoes. Corn roots frequently spread four to six feet laterally.

New branch roots are constantly produced, so long as the plant is growing. It is only the small new roots that have organs, called *root-hairs,* for absorbing water directly from the soil.

Root-hairs.—The root-hairs are very small, single-celled organs, produced in a zone near the tip of the new roots (Fig. 2). They function for only a short time, then die as the root extends, and new root-hairs are produced near the tip. Water is *not* absorbed by the roots, but *only* by the root-hairs. The root-hairs absorb soil water by a process known as osmosis.

Osmosis.—The sap of the root-hairs being denser than the soil water, the denser solution absorbs the weaker. This principle can be demonstrated with a slice of potato or apple. Put a tablespoonful

of salt in a glass of water, and drop in the slice of potato. In fifteen minutes it will be soft and shrunken, showing that some of its water has been extracted by the denser salt solution. Now place the slice of potato in pure water and it will soon recover its solid quality, due to the absorption of pure water by denser sap of the potato. The piece of potato can not continue to absorb, but with plants, the roots continue to take up water, as it is constantly being evaporated by the leaves.

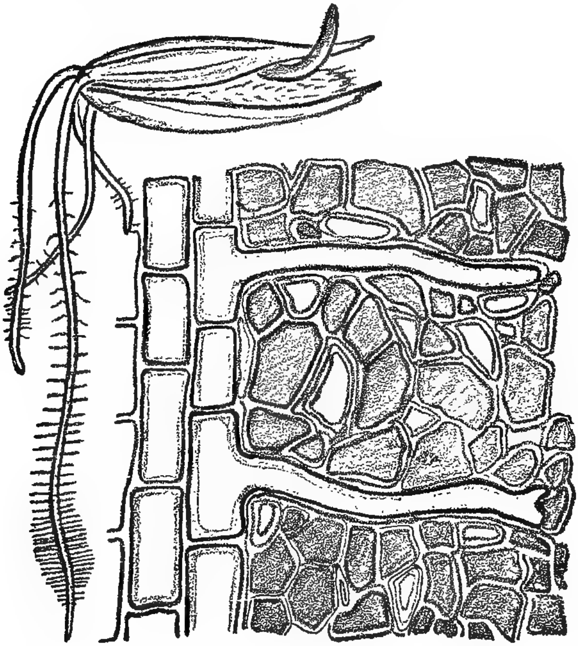

Fig. 2.—Root-hairs. On the right is a magnified section showing root-hairs in contact with soil grains.

Evaporation of Plant Water.—The soil water contains small quantities in solution of all the minerals a plant needs, but the solution is so weak that a barrel of soil water would scarcely contain a spoonful of minerals. Therefore, rapid evaporation of water is necessary, as large quantities of water must be passed through the plant in order that it may obtain sufficient mineral food.

The amount of water evaporated varies with climate and soils, but in general it requires from 300 to 500 pounds of water to each

pound of dry weight produced by the plant. More water is required in a dry climate than in a humid climate. At the Nebraska Experiment Station corn was grown in two greenhouses. In one the air was kept very dry, and in the other very humid. In the dry greenhouse it required 340 pounds of water to one pound of dry weight produced, while in the humid house only 191 pounds were required. The amount of water has been determined for several crops at various times with general results about as follows:

Amount of Water Lost by Evaporation and Transpiration for Each Pound of Dry Matter[1]

Oats	402–665	pounds
Red Clover	249–453	pounds
Barley	262–774	pounds
Corn	233–400	pounds
Wheat	225–650	pounds

LEAVES AND THEIR FUNCTIONS

The principal function of the leaf is to manufacture the raw food elements taken into the plant from soil and air, into "plant foods" or compounds that can be utilized by the plant in building up tissues.

Leaf Structure.—Examine a section of leaf under a microscope, and it will be seen to have several rather distinct parts (Fig. 3): (*a*) An outer covering, or "skin," called an epidermis. This is practically air- and water-proof. (*b*) Several layers of cells, a part being rather loosely grouped together, so as to leave air-spaces, and thus provide for the free interpassage of air among them. (*c*) Stomata, or air-holes, in the epidermis or skin. These stomata allow the free passage of outside air into the interior of the leaf. (*d*) The veins or circulating system. When the water solution is taken up from the soil, it passes up the stem through small vessels, which extend to all parts of the leaf. When the solution reaches the leaves, the water is quickly evaporated, leaving the plant food elements in the leaf to be manufactured. (*e*) The chlorophyll bodies are small green bodies scattered through the leaf, and these have the power of absorbing energy from the sunlight. The work of the leaf requires much energy, and this is all derived from the sun. No food

[1] American Society of Agronomy, vol. iii, p. 261 (1911).

can be manufactured, except in sunlight, though it has been demonstrated that strong artificial light will also produce growth.

Assimilation.—There are two general classes of products manufactured in the leaf, known as protein compounds and carbon-hydrogen compounds. *Protein* compounds are all rich in nitrogen but contain other elements as well. *Carbohydrates* do not contain either nitrogen or minerals, but are compounds of hydrogen, oxygen,

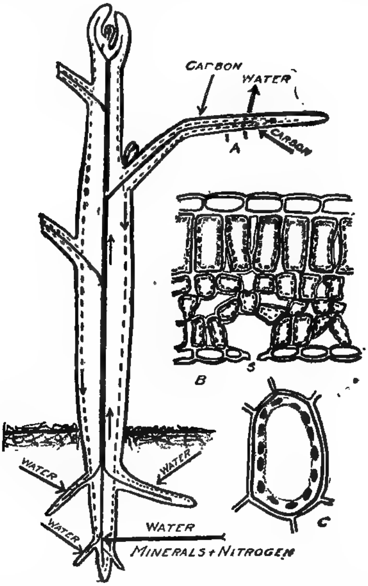

FIG. 3.—Diagram illustrating the assimilation of food materials by a plant. The water containing minerals and nitrogen passes upward into the leaves, where it unites with carbon and oxygen. The elaborated plant food then passes to all parts of the plant. The upward movement of water and return flow of plant food are through different channels. *B* is an enlarged section of leaf taken at point *A*. Note the opening for air at *S*. *C* is a single plant cell from the leaf. The dark spots are chlorophyll bodies.

and carbon, such as starch and sugar (Fig. 3). *Hydrocarbons,* or fats, also contain only hydrogen, oxygen, and carbon, but in a more concentrated form. Fats and oils are about 2¼ times as valuable as starch or sugar for feeding stock.

Distribution of Manufactured Products.—When the protein and carbohydrate compounds have been manufactured, they must be redistributed through all parts of the plant and some must be returned back to the roots. The return flow takes place through a set of vessels similar to the system which carried the sap upward.

Therefore, we have a continual flow of sap up from the root to leaves, also a continual inflow of air, containing carbon gas, into the leaves, where all is manufactured into plant foods and then returned in a similar way to growing parts of the plant.

EXERCISES

Testing the Effect of Fertilizers.—*Materials:* Nine 6-inch flower pots; soil; sand; greenhouse or sunny window in warm room; 10 grams sodium nitrate; 10 grams acid phosphate; 5 grams muriate of potash.

1. Select soil that is of good texture but known not to be very productive. Mix the soil with abo t one-half volume of sand. Fill the pots.

2. Now add the fertilizing material to each pot. The fertilizer should be ground up fine and thoroughly mixed into the soil.

3. Fertilize as follows. (1) One gram sodium nitrate. (2) One gram acid phosphate. (3) One-half gram muriate of potash. (4) One gram sodium nitrate; one gram acid phosphate. (5) One gram sodium nitrate; one-half gram muriate of potash. (6) One gram acid phosphate; one-half gram muriate of potash. (7) One gram sodium nitrate; one gram acid phosphate; one-half gram muriate of potash. (8) No fertilizers. (9) Ten grams fine barnyard manure.

Planting Seeds.—If you have a greenhouse or a good window in a warm room, use a cereal, as oats or barley, planting 10 seeds to each pot. If full light is not available use turnips, planting 10 seeds, but thinning to 5 plants.

Observations.—As long as the plants grow well, make notes twice a week on following points:

Size of plants.

Color—shade of green.

Place together all the 4 pots having nitrogen as one element and compare with rest for color and size.

Rank the 4 containing nitrogen in order of growth and decide which is best.

Rank the 4 pots containing potash.

Rank the 4 pots containing phosphate.

Which element seems to increase growth most? How is color affected? From your readings, which element is best for increasing forage production? Grain production?

COMPOSITION OF PLANTS

Determination of Water.—Take several samples of green or succulent plants, as corn, grass, turnips, and potatoes. Weigh at once, then cut up fine with a knife. Spread on paper and place in dry place for one week. Determine loss of water.

Then grind up finer and place weighed portion in oven at 110° C. (230° F.) and dry for two hours. Determine second loss of water. What per cent of green material was dry weight?

Take some air-dry hay and grain and grind very fine, then determine dry weight.

If possible, determine moisture in new corn and old, dry corn.

Identifying Starch and Protein.—It is sometimes difficult to get a clear understanding of starch and protein. The following exercise will help to an understanding:

Starch is identified by the use of iodine, giving a decided blue color.

Put a little water in a test-tube and add a pinch of cornstarch. Add a few drops of iodine solution (a 10 per cent solution is strong enough).

Shave down a corn grain from the germ side and test for starch by applying iodine with a brush. Do all parts show starch?

Test other cereals for starch; also peas, beans, and slices of potato, turnip, beet, and carrot.

Protein is identified by nitric acid, giving a bright yellow reaction. Test the same materials as above for protein.

Soak a few wheat grains until soft and make very thin slices with a sharp razor. Mount some in iodine solution (five per cent) and others in weak nitric acid. Examine under microscope for structure of cells and location of starch grains and protein.

Mount a bit of flour in each solution and examine. Is flour pure starch?

Loss of Water by Plants.—Grow a sunflower or castor bean plant in a six-inch pot. When six to ten inches high, prepare for the experiment as follows:

Water the plant well. Then cover the pot and soil with a rubber cloth or melted paraffine. This will prevent all water escaping except through the plant leaves. Now weigh the pot, and continue to weigh daily while plant lives.

Observe the daily water loss. Does it vary from day to day?

If a second plant be prepared in a similar way, and covered with an inverted glass jar, the water lost by the plant will be collected.

Moisture in Corn.—When corn is kept under different conditions its moisture content will vary considerably. Take samples that have just been husked, or husked corn remaining in the open, or corn from cribs, or corn from a dry seed room. Compare these samples as follows: Grind finely a few ounces of each sample in a coffee mill. Weigh one ounce or one gram of each. Then dry the weighed lots in an oven without burning, and reweigh each. Determine the percentage of moisture by dividing the loss in weight of each sample by its dry weight. Moisture in other grains may be determined in the same way (Chapter XXIV).

QUESTIONS

1. Name the principal parts of a plant and tell briefly the functions of each.
2. What do you understand by "element"?
3. How many elements in a plant?
4. Where does a plant get them?
5. How can a plant get elements from the soil?
6. How do plants get carbon?
7. Have you ever seen carbon?
8. What is "dry matter"?
9. How much dry matter in a bale (100 pounds) of hay?
10. If you burn the bale of hay, about how much ash will remain?
11. Where did the ash come from?
12. Where did the rest of the "dry matter" come from?
13. How long are plant roots?
14. What are root-hairs and what do they do?
15. Can you explain osmosis?
16. Why must plants take up so much water from the soil?
17. How does the water escape?
18. What do leaves do?
19. What is the "plant food" made by leaves?
20. How does it get to other parts of the plant?
21. How does protein differ from carbohydrates?

CHAPTER III

THE PRODUCTION OF SEEDS

Function and Use of Seeds.—Every plant must be provided in some way with a sure method of reproduction, or its kind would soon pass out of existence. This is especially true in wild nature, where the plant must care for itself, and is subject to all manner of competition from other plants and to adverse conditions. Most of our cultivated plants are produced from seeds, though a few are from cuttings, as orchard trees, or new plants are produced by runners, as in the strawberry.

The seed or fruit of plants is also the portion which we use principally as food, for both men and animals. The plant stores up energy as food for the young plant, as in the seed of wheat or the tuber of potato. In certain root crops, as the turnip, food is stored for a time in the enlarged root, to be later used in the production of seed. In any case, we have come to rely on this stored food of the plant, either in the seed, tuber, fruit, or root, as our principal source of food for men and animals.

Nature of Seeds.—A seed may be regarded as a young plant, in a dormant state, with a large supply of stored energy at hand ready to be used when the time comes for growth.

The seed consists essentially of three parts: (1) The young dormant plants called the germ. The germ constitutes 5 to 10 per cent of the seed. (2) The stored food, called the endosperm in cereals, or cotyledons in legumes. This part of the seed equals about 90 per cent. (3) The seed-coats, a strong protective covering, equal to about 3 or 4 per cent of the seed. In the cereals (wheat), the germ is very rich in protein and minerals, and the endosperm is mostly starchy, while in the legumes (bean) the whole seed is rich in protein and starch.

Preserving the Vitality of Seeds.—Preserving the vitality of seeds is a matter of the greatest importance if good crops are to be produced. Dry seeds contain about 10 to 14 per cent moisture. When

dry, most seeds retain vitality for many years, and are not injured by ordinary freezing or even high temperatures up to 140° F. In humid air, such as a damp cellar, or very often sea-coast climates, almost all common seeds will deteriorate, even when kept at average temperature. They lose power to germinate in a few months to one year. Free circulation of air is necessary while seeds are drying, but when they are thoroughly dry this does not seem to be necessary. As there are damp periods of weather now and then, when seeds in storage are quite apt to take up moisture, it is always well to provide free circulation of air in seed houses.

Good Seeds.—Two things are required of good seeds. First, they must have grown and developed in a normal way, so as to have vigorous germs and a good store of food. Second, the vitality must be retained. All that is necessary to preserve the vitality of seed is to thoroughly air dry the seed, as soon as mature, and keep in dry storage.

Duval [1] took seeds of various kinds, mostly vegetables, and stored them in ordinary paper envelopes and also in corked bottles. These seeds were then placed in storage in several cities, namely: Lake City, Fla.; Auburn, Ala.; Mobile, Ala.; Baton Rouge, La.; San Juan, P. R.; Wagoner, Ind. Ter.; Durham, N. H.; Ann Arbor, Mich. In each place they were stored in three ways: (1) Trade conditions or ordinary unheated rooms; (2) dry rooms, which were dry inside rooms, artificially heated, at least part of the time, and (3) basements.

The average *loss* of germination after storage for 251 days was as follows:

	Envelopes	Bottles
Trade conditions	36.63	3.92
Dry rooms	21.19	8.08
Basements	42.28	4.51

This shows that dry seeds, stored in such a way as to keep them dry, will retain vitality even when stored in basements. However, seeds *not* thoroughly dry, stored in tight bottles, deteriorate very rapidly.

[1] Duval, J. W. T.: The Vitality and Germination of Seeds. Bureau of Plant Industry, Bul. 58.

How Germination Takes Place.—The dry seed is in a dormant state, with all life processes practically arrested. When proper conditions are present, all the life processes are started anew and growth begins.

Before growth can take place, three conditions are necessary: (1) There must be sufficient moisture, so the seed can secure all it will readily absorb. (2) There must be air present. If the soil is so compact and filled with water that no air can reach it, the seed will rot. Whereas, pure oxygen was given off when the plant developed starch and stored energy, the plant must now take up oxygen by oxidizing or "burning" some of the carbohydrates. (3) There

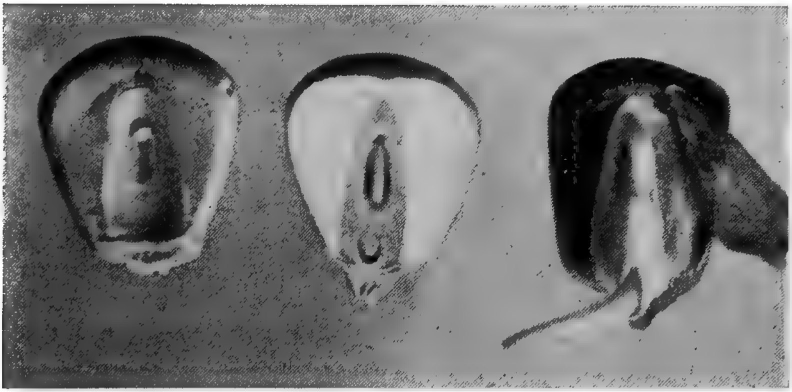

FIG. 4.—Germination in corn. On the left is a kernel of corn before germination, while the center shows a similar grain, with the surface shaved off to expose the germ. On the right is a kernel beginning to germinate.

must be sufficient heat. Some seeds, as clover or oats, will grow at rather low temperature (40° to 50° F.) and start growth very early in the spring. Other crops, as corn or beans, require a higher temperature for best growth (70° to 80° F. is most favorable), and should not be planted until the ground is warm. When proper conditions for germination are present, seeds begin to grow (Fig. 4). Certain active agents in the seed (enzymes) begin to dissolve the stored plant-food, converting starches into sugars, so they can be readily absorbed by the growing plant.

When Seeds Sprout.—In two to four days after seeds have been placed under favorable conditions, the "sprouts" begin to appear.

The young plant breaks through the seed-coat and grows upward. At about the same time, three or more roots in the grasses break through and grow downward (Fig. 5). For a few days, the young plant and roots depend on the seed for food. When the plant has reached sunlight with its leaves, a new set of true roots have made their appearance just below the soil surface, and the plant is no longer dependent on the seed for maintenance. When the soil conditions are good, the plant is quickly established and only a small

FIG. 5.—Wheat grain in three stages of germination, on the first, second and third days after being placed in germinator (compare with Fig. 8).

proportion of the stored food is actually required. When soil conditions are poor, the plant may draw on the seed for a long time. The seed alone will maintain the plant for two weeks. Large plump seed is probably more important when conditions are unfavorable, than when conditions are such that the plant can quickly establish on its own roots.

Large and Small Seeds.—Examine a handful of wheat or corn, as harvested, and great variation in size of seed will be noted. In some cases, a part of the seeds will be very much shrunken. The comparative merits of large and small seeds for planting are often

discussed. With corn, the experiment has been tried many times, of planting the large kernels from the middle portion in comparison with the smaller seeds near the ends of the ear. Very little difference in results is secured, as both kinds of kernels from the same ear have the same hereditary qualities. It appears also that large and small kernels from the same plant of wheat carry the same qualities and ability to produce. Seed grain is sometimes run through a set of screens to separate the large seeds from the small. However, if the seed grain is good, sound grain, it is doubtful if it will pay to make such separation. This conclusion is based on experiments reported by the Ohio,[2] Kansas,[3] and Nebraska [4] Experiment Stations.

Shrunken Seeds.—The removal of shrunken seeds may be beneficial where the percentage is high, and the soil or climatic conditions unfavorable. However, when sufficient seed is sown, it is doubtful even if the presence of more or less shrunken seed will have much effect. When cereals are sown at customary rates, so many plants come up, that weak or slow plants are crowded out during the early stages of growth. As this natural selection is going on every year in cereal crops, they maintain their natural vigor and productiveness much better than crops planted far apart, as corn or potatoes, and thus relieved from natural competition.

Structure of Seeds.—All students should have a knowledge of the structure of seeds and the factors that influence growth.

The Food of Seeds.—The seed is a storehouse of food for young plants. Seeds may be divided into two groups, according to the way food is stored:

1. Food stored in *cotyledons,* or first two leaves.
2. Food stored in *endosperm.*

Seeds of the first class can be known when they germinate in the soil, because the seed divides into halves, which are firmly attached to the young plant. In some cases, the two halves of the seed are pushed above ground, becoming the first two leaves. The young plant, however, draws its first food supply from these leaves.

Seeds of the second class remain whole and below ground, as the endosperm is only a storehouse of food.

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[2] Ohio Bulletin 165.
[3] Kansas Bulletins 59 and 74.
[4] Nebraska Bulletin 104.

The two kinds, however, can be told by examination of the seed itself.

EXERCISES

Study of Seeds and Seedlings.—Soak a few seeds of beans and corn. At the same time start seeds of both to germinating; also plant seeds of each 3 inches deep in soil.

(*a*) Take one of the beans and remove the skin and separate the two cotyledons.

Make a drawing (5 times enlarged) showing the little plant. Label all parts.

Take a germinated seed. Make a drawing and label all parts.

Make a third drawing of a plant grown in soil, about two weeks old. Label all parts.

FIG. 6.—On the left a germinator made by inverting a glass tumbler on a glass plate. The seeds are placed on wet blotting paper. On the right a germinator made with two plates and blotting paper.

(*b*) Take a corn grain, which has been softened by soaking, and shave down on germ side until germ is fully exposed.

Make drawing and label all parts.

Also make drawings of germinated seed and plant two weeks old..

(*c*) Write up a short statement explaining how the plant lives while developing its root system. What are temporary roots and permanent roots?

Germination of Seeds.—Germination tests are important, interesting, and easy to make, if properly managed, yet very poor results are often obtained.

The main points to observe are to keep the seed moist, and at a temperature ranging from 50 to 80 degrees. In general, it will take only one-half as long to germinate seed at a temperature averaging 70 as compared with a temperature of 50 degrees. There are exceptions, however, as a few seeds, such as the clovers and a few grass seeds, germinate well at the lower temperature.

Apparatus for Germination.—Many homemade germinators have been devised, but those here described are recognized as best.

1. *Plate germinators* are made by using two dinner plates or pie tins (Fig. 6). Two or three layers of blotting paper or a half inch of sand covered by cloth are placed in the bottom of one. Saturate the absorbent well and place the seeds on top. Then invert the second plate over the first, being careful that the edges fit well.

2. *Box germinators* of several types have been devised, but the following one has many advantages:

Fig. 7.—A box germinator. A tin box with two sawdust pads. Can be carried about.

Have a tin box made 12 to 15 inches square, with a hinged lid which can be fastened shut with hasps. The box and lid should each be about one inch deep. Make two pads stuffed with sawdust. The pads should be the size of the box and an inch thick, so that when put into the box and lid, and the box closed, they will fill it snugly.

For germinating seeds, first saturate the pads, then place the seeds on one, close the box and fasten. The box should be opened a few minutes each day to admit air.

This box has many advantages, as it can be easily moved, placed in any position, or carried to and from home or school (Fig. 7).

Jelly Glass Germinators.—Take jelly glasses with a loose-fitting tin lid. If the lid is snug, it can be easily spread by reaming with a knife handle or piece of iron. Place a few pieces of wet blotting paper in the lid, scatter

on the seeds, and invert the jelly glass over them. One advantage of this germinator is that the progress of germination can be observed from day to day. See also the plan shown at left in Fig. 6.

For class-room work it is often useful to start one of these germinators each day for a period of 10 days, thus having material for study in all stages of development.

Rag Doll Germinators.—This germinator is made by using a strip of flannel, about 10 inches wide. Place the seeds on one-half, fold over the other half, then roll and tie loosely. Soak in water for 12 hours, then put in a box or some place where they will remain damp.

Seeds to Use.—Have the pupils bring seeds from home, from the supplies that are to be planted on the farm. Vegetable seeds, grass, clover, and cereal seeds of all kinds will serve well. Old seeds as well as new should be used. Seeds from local dealers can also be purchased. When the tests are completed the data should be studied and analyzed to see if it can be determined why some seeds are good and some are poor.

Comparison of Germinated Seeds.—There are several differences in germinated seeds of cereals that few people have observed. For this exercise only good, strong seeds should be used, and special care should be exercised to secure normal, strong germination.

Germinate seeds of all the cereals, and also peas and red clover.

When well germinated, study 10 seeds in each case. Record results in tabular form.

What are the average number of temporary roots in each cereal?

State in each case whether the plumule arises from the germ end, middle, or tip of the seed.

Which germinates quickest, slowest, etc.?

In a second experiment compare strong seeds with poor seeds, and compare on above points.

In a third case compare seeds of hard wheat and soft wheat; hard and soft grains of barley; and kernels from ears of dent corn having hard, flinty kernels with ears having starchy kernels.

Can you explain why the hardness of a seed should affect the rapidity of germination? Should this be considered in making comparative germination tests with different ears of corn or different varieties of wheat? (See also Chapter XXXV.)

QUESTIONS

1. Why do plants store food in seeds?
2. What other parts are sometimes stored with food?
3. What part of plants do we value most as food?
4. Name the parts of a seed.
5. Give the function of each part.
6. What is the best condition for preserving the vitality of seeds?
7. How would you define "good seeds"?
8. Why is air important in germination?
9. Do some seeds require warmer temperature for growing?
10. How long must the young plant live on the seed?
11. When may large and small seeds be expected to give similar results?
12. When different results?
13. How are weak plants eliminated in nature?

CHAPTER IV

COMPARATIVE STUDY OF CEREALS

IN the germination of cereals some interesting comparisons are noted. First, the young roots appear, then the plumule or young plant. In corn, wheat, and rye the young plant arises directly from the germ, but in oats and barley the grain is enclosed in a husk and the young plant grows under the husk, emerging at the opposite end of the grain (Fig. 8).

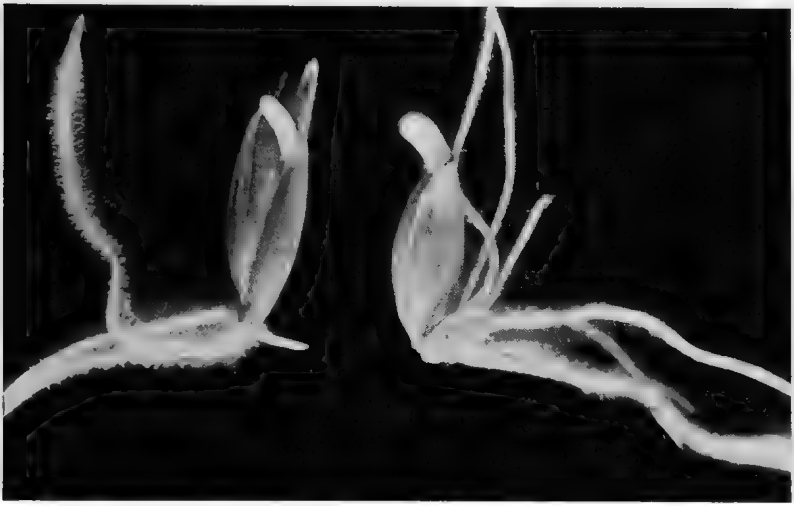

FIG. 8.—Germinating oats, on left, and barley, on right. Note that oats has three temporary roots and barley six (compare with Fig. 5).

The young roots are usually 3 in number in corn, wheat, and oats, but usually 4 in rye and 5 or 6 in barley. The number of roots on germination is not exact; for example, in corn the number may vary from 2 to 5, but is *usually* 3.

Temporary and Permanent Roots.—The first roots emerging are called *temporary* roots. They only assist the young plant while it is becoming established, and probably supply water mostly as the young plant at first lives largely on the stored-up food in the seed.

The young *plumule* stretches upward and somewhere just below the surface forms the first node. The first node usually forms about the same distance below the surface, and its height above the seed will depend on how deep the seed is planted (Fig. 9). This first node becomes the *crown* of the plant and here the permanent roots form. At this point a number of short nodes form and from these

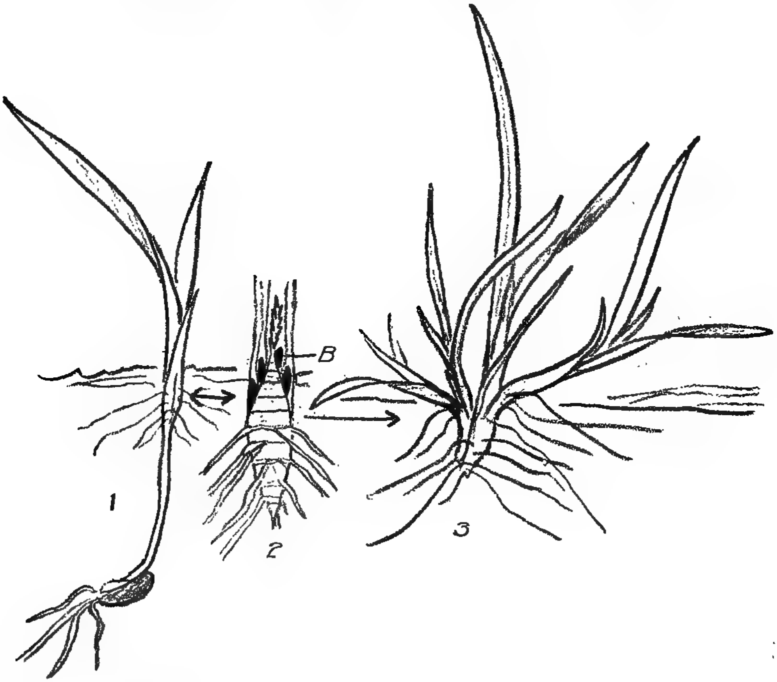

Fig. 9.—(1) Illustrates a young wheat plant forming first permanent roots, near surface of soil. (2) Is an enlarged section with leaves removed to show the "buds" or new tillers forming. (3) Wheat plant about six weeks old with tillers developed.

the *permanent* roots come out. The roots are arranged in a series of rings about the base of the plant. Just above the roots come out the first leaves and first buds to form tillers. This is characteristic of all the cereals, but is most easily seen in a corn plant, because of its large size.

Tillers.—If a young plant of corn or wheat be examined when about three weeks old it will usually have about a half dozen leaves

arising from the crown, and if these be carefully removed a small *bud* will be found at the base of each leaf. These buds develop into branches or "*tillers.*" The number that develop, however, depends on conditions. If the soil is poor or cold, so growth is not vigorous at first, perhaps no tillers will develop, while very favorable conditions will stimulate the buds to growth. Hence we find that on cold, clay soils plants seldom tiller so freely as on warm, sandy soils. Crowding the plants by thick planting also suppresses the tillers, while thin planting favors them. Wheat plants placed wide apart, 6 to 8 inches each way, on rich soil will produce 10 to 20 stems from a seed, but under ordinary field planting not more than 2 or 3. The following data, from the Nebraska Experiment Station,[1] shows the effect on tillering of oats with different rates of planting:

Tillering of Oats

Pecks of seed sown per acre	Stems per 100 plants	Total number of stems per acre
4	466	1,419,000
8	279	1,732,000
16	140	2,283,000

The Stems of Cereals.—The stem of corn is filled with pith, but in wheat, oats, rye, and barley the stem is usually hollow, with solid joints or nodes. However, in a few wheats, as the spelts, the stem is partly or entirely filled with pith. The number of joints in corn varies from about 8, with short early varieties, to 12 to 14, with tall late varieties. In the small cereals 4 or 5 nodes is the usual number.

One leaf arises from each node, the largest leaves coming from about the middle of the plant. In wheat there are usually about three leaves on the stem, and in oats about four.

The Ear or Head.—In all the small grains (wheat, oats, barley, rye) the ear is borne at the top, but in corn only the tassel or male flower is borne at the top, while the ear is borne on the side. Both the male and the female flowers are borne in one head (called perfect flowers) in the small cereals, but in corn are separated in the tassel and ear. Since all cereals are grasses, the structure of the head and flower is similar in the main features, but varies in details. To understand the structure fully a careful comparative study of details

[1] Nebraska Bulletin 127, p. 18.

should be made of a typical grass first, and then all the cereals in comparison.

The Spikelet.—The central part of the wheat head is called a *rachis.* On the rachis are the *spikelets.* If the spikelets are attached directly to the rachis, so a compact head is formed, as in wheat, the whole is called a *spike.* If the spikelets are on long branches, as in oats, the whole is called a *panicle.* The typical grass spikelet is made up of two empty glumes and one or more fertile flowers above (Fig. 10).

Fig. 10.—Comparative study of spikelets. From left to right the spikelets shown are, brome-grass, barley, rye, oats, wheat, corn. Below are shown the two empty glumes in each case. In corn the glumes are much reduced, but a careful study will show analogous parts in all spikelets.

The Flower.—A grass flower consists of one fertile glume or *flowering glume,* and *palet* enclosing one *ovary* and three *stamens.* A careful comparison will show that all the cereals conform to the above description, except in corn, where the stamen flowers and ovary flowers are separated, but are otherwise similar.

Fertilization.—When the time has arrived for the flower to be fertilized, the glumes open and the stamens come out. The pollen sacs burst, freeing the pollen in the air. At about the same time the stigmas spread out to receive pollen. When a pollen grain drops on a stigma the contents of the pollen grain immediately pass into the

stigma and down into the ovary. This is called fertilization, and causes the ovary to immediately develop into a seed (Figs. 11 and 12).

Cross- and Self-Fertilization.—When the pollen produced by a plant fertilizes its own ovaries, we call it *self-fertilization.* When the pollen is carried by the air or by insects to other plants, we call this *cross-fertilization.*

In the cereals we find barley is always self-fertilized; in fact, the fertilization takes place before the heads emerge from the sheath. Wheat and oats are also considered self-fertilized, but as the head

FIG. 11.—Diagram of a wheat flower, showing the ovary, with feathery stigmas, and the stamens or pollen sacs dropping pollen.

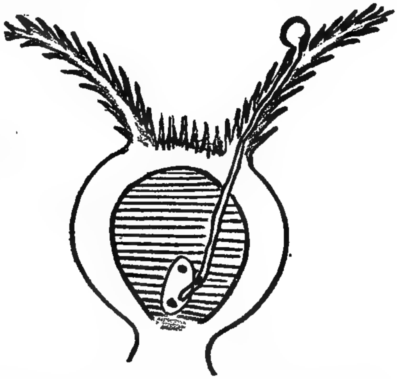

FIG. 12.—Ovary of wheat grain. A pollen grain caught on the stigma has germinated and penetrated to the egg-cell. The contents of the pollen grain pass to the egg-cell, causing fertilization. The egg at once grows into a wheat kernel.

is fully exposed when the fertilization takes place there occasionally happens a natural cross. In barley, wheat, and oats each ovary receives pollen from its own stamens before the flower opens.

Rye and corn are cross-fertilized. In rye the pollen in each flower ripens before the stigma is ready and is, therefore, scattered in the air, the stigma receiving pollen from another plant a day or two later. In corn the pollen is in the tassel and is carried away from its own ear by air currents, but in both rye and corn at least a few seeds are usually self-fertilized. By experiment, it has been shown that self-fertilized seeds in corn or rye will not produce as strong

plants as crossed seeds, and continued self-fertilization will result in dwarf plants with very low productivity. It is entirely different with barley, wheat, and oats, as they are self-fertilized with no ill effect and apparently are not benefited by crossing.

Formation of the Seed.—When the contents of the pollen grain pass down into the ovary they unite with the *egg-cell* in the ovary. Growth in the ovary begins at once. One part of the egg develops into a young plant or *embryo,* while another portion develops into a storehouse of food for the young plant and is called the *endosperm.*

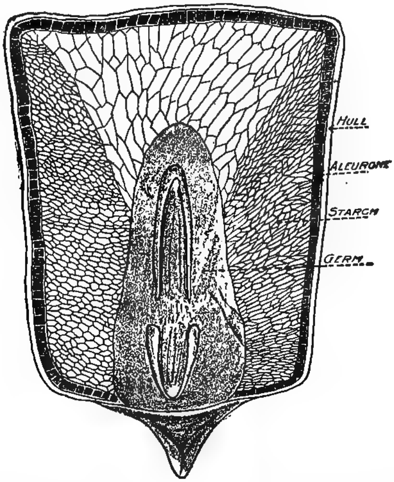

FIG. 13.—Diagram of a corn kernel to show the four principal parts, namely, hull, aleurone layer, endosperm or starchy portion, and germ.

The whole is called a seed, as wheat or barley grains. The wheat grain is covered with a seed-coat, which is only the remnant of the old ovary after the young plant and its storehouse have developed inside. In milling, the seed-coat is taken off as bran.

Composition of the Seed.—The seeds of grasses are said to be starchy, consisting in general of 75 to 85 per cent starch (Fig. 13). The grain, however, can be divided into four parts—(1) seed-coat, (2) aleurone layer, (3) endosperm, (4) germ—each very different in composition, and the proportion of these parts affects the composition of the whole grain.

Proportion of Each Part and Composition in Corn[2]

	Per cent of whole kernel	Chemical composition: Protein per cent	Oil per cent	Ash per cent	Carbohydrates per cent
Seed-coat, including tip cap	7.3	4.0	1.1	1.0	93
Aleurone layer	11.2	22.0	5.0	1.4	71
Endosperm	70.3	9.0	0.3	0.3	91
Germ	11.2	20.0	35.0	10.0	35
Whole corn	100.0	11.3	4.0	1.5	82.8

The seed-coat is high in carbohydrates, but this is mostly in the form of fiber. The aleurone layer is rich in protein. The endosperm is rich in starch, while the germ contains most of the ash and oil of the kernel and is also rich in protein.

While the above composition of parts applies in a way to all cereals, yet there is much variation. For example, wheat, oats, and barley have a smaller germ than corn, usually only 4 to 5 per cent instead of 11 per cent; also they have less seed-coat and more endosperm.

Composition of Cereals.—While the above table shows the general composition of a cereal grain it can not be said that there is a constant or definite composition, as no two ears of corn or samples of wheat will analyze alike. The following table gives a general summary of analysis of the cereals, as compiled in United States Bureau of Chemistry, Bulletin 120, but even this can not be relied on as a final comparison, since other general averages will vary from this.

Composition of Cereals (Water Free)—Pounds Per 100 Pounds

Grain	Protein	Fat	Crude fiber	Carbohydrates
Oats	13.7	4.3	12.2	66.3
Wheat	14.2	2.3	2.8	78.7
Rye	13.4	1.8	2.3	80.2
Barley	13.3	1.8	5.6	76.0
Corn	10.0	4.4	2.2	81.9

Any particular sample may vary widely from the above. For example, different samples of wheat may vary from 9 to 16 per cent protein, and corn may vary from 3 per cent to 7 per cent in fat, and so on, but in general we consider oats and wheat to be richer in

[2] Illinois Bulletin 87.

protein than corn and barley, while corn and wheat are richer in starches. Corn and oats are rich in fat. Oats and barley are high in crude fiber, due to the hull.

Composition of Hard and Soft Grain.—In all the cereals there is a great difference in the hardness of grain in different varieties. We have the "hard wheat" with flinty, hard grains, as the durum wheats and northwestern spring wheats. Then we have the "soft wheats," usually white or light red in color and showing a white, starchy interior. In wheats we find that the hard wheats are high in protein, with 13 to 16 per cent, while the soft wheats have only 8 to 11 per cent. The same is true in barley, ranging from 8 per cent protein in soft barleys to 15 per cent in hard barleys.

In corn, however, we have a very different case. Corn is even more variable in hardness than wheat, ranging from the hard popcorn and flints to the soft flour corns, but there is no corresponding difference in composition. If we take a grain of dent corn, which is made up of both hard and soft endosperm, it has been found that there is a difference in composition, the hard portion being about 2 per cent higher in protein; but between different types of hard and soft corn there is no such general difference as is found in wheat and barley.

Effect of Climate on Composition.—Again we find with wheat and barley that in a dry climate hard grain is produced high in protein, but in a humid climate, or one with cool summers, the wheat is soft. Hence we find the great "hard wheat" districts in the dry, hot climate west of the Missouri River, while soft wheat is produced in the East and South. With corn, however, the composition and character of grain is not apparently affected by climate.

Little is known about the effect of climate on the composition of rye and oats, but it is believed that rye should be classed with wheat and barley, and oats with corn.

Moisture in Grain.—In considering the composition of cereal grains we have made no reference to water present, as grain is artificially dried before analysis. However, air-dry grain in a humid climate contains from 12 to 14 per cent water, and in a dry climate less. For example, in the Palouse Valley, Washington State, during the very dry summer of 1914, the wheat generally contained less than 5 per cent moisture. Grain shipped from a dry to a humid climate

will gain in weight, or the reverse may be true when shipped from humid to dry region.

EXERCISES FOR FIELD AND LABORATORY

Comparative Study of Cereals.—All cereals are large grasses. All cereals and grasses are similar in general structure. Every student should have a good knowledge of the anatomy of at least one cereal. Corn, being a large plant, lends itself well to such study.

General Structure of Cereals.—Before completing the work, read over such parts of Chapters IV and VI as refer to general structure.

For material use a well-developed corn plant, including roots.

1. With a sharp knife, split the plant from the lower tip of the stem to the tassel, in such a way that the buds and ear shanks are also split.
2. Make drawing of root section, showing nodes and permanent roots.
3. Find a section (split) showing a tiller. Make drawing, being careful to show how tiller is attached.
4. Make drawing of any node showing an ear bud. Indicate leaf by dotted lines.
5. Make drawing of ear, shank and ear (split) with husks.

Note whether the number of nodes in the ear corresponds to nodes in stalk, above ear. Do the husks correspond to leaf sheaths? Do you find evidence of the ear stem being a side branch, "telescoped" into the husks?

6. Make drawing of whole plant, indicating exact number of nodes both above and below ground. Indicate correctly the outgrowths from nodes, as roots, buds, leaves, and ears.

Relation of Tassel and Ear:

7. Sketch tassel.
8. Sketch pair of tassel flowers (x2, *i.e.*, double size).
9. Sketch section of *central* portion of tassel.
10. Sketch cross-section of ear.
11. Sketch kernel showing chaff at base (x2).

Write up brief report as follows:

Describe relation of ear and tassel. Relation of ear branch and a tiller. How many ear buds? Ears? Leaves? Husks on an ear?

Comparing the Spikes and Flowers.—All spikes of cereals and grasses are similar in structure, though it may not appear so at first.

Lay out in a row:

1. Spikes of grasses, as timothy, rye-grass, etc.
2. Spikes of cereals, as wheat, oats, barley and rye.
3. Spikes of corn, as tassel and ear.

(*a*) Determine what a spikelet is, using oats for this study. Draw all the parts of a spikelet and label same (drawing 3 times enlarged).

(*b*) Draw a wheat spikelet.

(*c*) Draw a barley spikelet.

(*d*) Now isolate a spikelet from each of the spikes which you have laid out as above. See if you can identify analogous parts in each case.

Write a concise statement defining (1) spike; (2) spikelet; and (3) flower.

Compare the central spike of a corn tassel and an ear of corn, and work out the analogous parts.

To what does the hull of oats correspond in the wheat flower?

How many kernels per spikelet are usually found in wheat, oats, barley, rye, corn, millet, brome-grass, and rye-grass?

Further Study of Tillers and Roots.—Visit fields of wheat or oats that have been recently sown.

Search for plants in all stages of development, from those just coming up to well-developed plants 4 or 5 weeks old.

Make sketches showing all stages, especially noting the development of tillers and permanent roots.

Does the depth at which roots and tillers develop appear to be affected by depth at which seed is sown?

Do plants tiller more in some parts of the field than in other places? Is tillering related to richness of soil? To rate of planting? To time of planting?

QUESTIONS

1. How do germinating wheat and barley grains differ in appearance?
2. Explain about the temporary and permanent roots.
3. How is the "tiller" related to the main stem?
4. How does rate of planting affect the number of tillers?
5. What is a node? An internode?
6. How do the flowers in corn differ from those of wheat?
7. Name the parts of a wheat head. The parts of a wheat flower.
8. What is fertilization?
9. Define cross- and self-fertilization.
10. Give examples of plants that normally self-fertilize and cross-fertilize.
11. What is the egg cell?
12. What part of the seed is highest in protein? Oil? Ash? Carbohydrates?
13. Which part do you think would have greatest feeding value?
14. Which of the cereals are highest in protein? Fat? Fiber?
15. Do hard and soft grains of wheat differ in color? Composition?
16. How does climate affect composition of wheat? Barley? Corn?

CHAPTER V

CROPPING SYSTEMS

Where Did Soils Acquire Productiveness?—Dig into the earth any place and "bed rock" will be found. Sometimes bed rock is exposed above the surface and sometimes buried under many hundred feet of soil. Originally, all the surface was rock, but a portion has been slowly and gradually reduced, by such agencies as glaciers, freezing, and rain water containing carbonic acid. Gradually as this rock was pulverized, it accumulated where other agencies, as plants and bacteria, worked on it further.

Pulverized rock might contain all the minerals needed by plants, but our common field crops would not grow in pulverized rock, as may be easily demonstrated. There are two reasons for this: First, the minerals are not soluble in water; and second, the rock is devoid of nitrogen.

How Rock Minerals Become Soluble.—Rain water contains some carbon dioxide, which is a weak acid and has a slow solvent effect on certain minerals of the soil. Enough minerals would be leached out to support aquatic vegetation. This aquatic vegetation mixed with soil would decay and produce organic acids, that in turn would break down the insoluble minerals.

Certain plants, as lichens, also live on rocks, and excrete acids that liberate enough minerals for their own use. When some organic matter was finally mixed into sterile soils, other agencies, such as bacteria and a variety of plant life, could live, and finally heavy vegetation could flourish. On our forest lands, trees have grown for ages, and the decaying leaves, branches, and roots have added large quantities of organic matter. On the prairies, grasses have grown up, to die on the land each year. In this way the available mineral supply of the soil has been slowly accumulated.

Where Nitrogen Came From.—While nitrogen was not found in the rock from which soil was made, it is the most important element of the air, constituting about four-fifths of the atmosphere, or 35,000 tons over each acre of land. Very small quantities of

nitrogen are brought down by rainfall, while soil bacteria fix rather large quantities of nitrogen taken from air circulating through soil. These bacteria are the principal natural means by which nitrogen is fixed. Some forms of these bacteria are associated with legumes, while others are capable of living in the soil and fix free nitrogen, if organic matter is present. It is not known which kind have been most important in fixing the present supply of nitrogen in the soil. There is some evidence that in certain soils in rather dry regions, as Colorado or Utah, soil bacteria not associated with legumes may fix large quantities of nitrogen from the air.

Nitrogen Fixed by Legumes.—The nitrogen is not taken from the air by the legume plants as might be implied, but only by the bacteria found in the nodules formed on legume roots. These bacteria are short-lived and, as they die, their nitrogen becomes available to plants. Legumes also use any available nitrogen in the soil.

A ton of alfalfa hay may contain 50 pounds of nitrogen, yet four tons a season may be removed, and still the soil be richer in nitrogen than before. This would indicate that an alfalfa crop is capable of fixing 200 to 300 pounds of nitrogen from the air in a season, or forty to sixty dollars worth per acre based on the commercial price of nitrogen. Nitrogen in fertilizers costs about twenty cents a pound.

In nature, there are great numbers of wild legumes which have been adding their annual deposit of nitrogen to the soil for ages. This is especially true in prairie regions and is one reason for the rich store of nitrogen in these soils.

Importance of Organic Matter.—A large supply of organic matter is important for the following reasons:

(*a*) By decaying in the soil, it makes available plant food.

(*b*) It is necessary for the life of nitrogen-fixing bacteria.

(*c*) The decayed organic matter itself becomes food for plants.

(*d*) Vegetable matter in the soil helps to keep the soil moist and in good tilth, so it will not become hard and bake.

From the above, it would seem that the most important means of keeping a soil productive without the use of fertilizers is to maintain a good supply of vegetable matter, and grow legumes a part of the time to keep up the nitrogen supply (Fig. 14).

Effects of Cropping.—When the timber was cleared, or the prairies were broken up, the land was generally productive. After the land has been farmed 40 or 50 years, the productiveness has usually decreased on the average farm, so that not more than one-half the corn or wheat is produced with the same effort. A few farms, that have been well-handled, will still be productive, while, on the other hand, some farms will be so poor that the owners abandon them.

FIG. 14.—Plowing under rye for green manure.

The effect of cropping has just reversed the work of nature. (1) By the constant removal of crops, the humus has been exhausted and none returned. As a result, the soil becomes hard, dries out quickly and there is no longer decaying vegetable matter to free new supplies of minerals. (2) Sometimes one or more minerals have been exhausted and none returned. (3) The nitrogen is exhausted and no legume grown to return it. (4) The lime is often leached out.

In most cases, the problem of making this exhausted land productive again is to change the farm practice, put back what has

been taken out and adopt a cropping system that will restore the land to its original condition.

Some farms will be found that have remained productive under good farm management and other examples may be found, where unproductive land has been restored by good cropping systems.

Single Cropping System.—When new land has been broken up, the general custom has been at first to grow principally only one or two kinds of exhaustive crops—usually the crops that pay best, as corn, wheat, or cotton. In the newer lands of the west (the Dakotas and Canada), we may find the "wheat belt," where wheat has been grown continuously for 20 years. Usually when land has been in one crop for 20 years, it no longer pays and farmers must alternate crops.

Alternating Crops.—East of the wheat belt, where land has been farmed 40 years, farmers have found it necessary to alternate grain and cultivated crops, as wheat and oats with corn. This alternate cropping will maintain yield for a time, but the humus, minerals and nitrogen slowly exhaust, and it then becomes necessary to restore these to maintain the yield.

Rotation Farming.—Coming east to still older farming sections, as Illinois and Indiana, all good farmers have for years been adopting rotation systems, that provide for alternating the cultivated crops and grain crops with clover and grass; the clover and grass to occupy the land from one-fourth to one-half the time. In addition, effort is made to return much of the straw removed with the crops, in the form of manure, while in the early days, little or no manure was returned. A good rotation system will not only restore productivity to much unproductive land, but will maintain it for many years. If in addition to a good rotation, the crop is fed to live stock and the manure returned, the land may be kept up almost indefinitely.

What the Rotation Does.—The rotation of crops (1) maintains the humus supply; (2) restores nitrogen; (3) alternates crops, having different root systems and habits of growth; (4) helps control weeds, fungus diseases, and insects.

(1) If land is continually sown to grain crops, the humus supply of the soil will decrease. Constant stirring of soil causes the oxida-

tion or "burning out" of humus. If the same land is sown to grass, the humus supply will be maintained or increased. With manure on grass, the humus may be increased.

(2) Experience indicates that where clover is grown once in four years, the nitrogen supply can often be maintained, even when the clover is not plowed under.

(3) Plants having quite different root systems, as legumes, root crops which have deep tap roots, and grains having fibrous roots, may live on the same land with less competition than when all have similar root systems. The same is probably true of plants having different habits of growth, as wheat, which grows principally in early summer, and corn, which grows in late summer.

(4) Most weeds that trouble grain crops are destroyed when the land is put to grass. Most weeds are easily controlled under rotation. Certain injurious insects may become abundant when the land is in the same or similar crops. For example, corn root worms live only on corn roots, and may accumulate in great numbers when the land has been in corn for several years, but all are destroyed when the land is put in some other crop a few years. In the same way, some plant diseases are controlled by changing crops.

Aside from maintaining productivity, rotations help in other ways by distributing the labor, and decreasing chance of total loss of crop in bad crop years.

Rotations Do Not Keep Up Mineral Supply.—While a well managed rotation, with manure, may keep up the humus and nitrogen, it will not keep up the minerals. In fact, it may exhaust minerals faster than single cropping, since a 30 bushel crop of wheat removes more minerals than a 15 bushel crop, and nothing is done in a mere rotation to return minerals.

In most cases, the soil was well exhausted of at least some mineral element before rotation was adopted. Ultimately on most soils, minerals must be supplied in some form. In the oldest farmed sections of the country, namely, the New England States, rotations are no longer sufficient and farmers find it necessary to add some minerals in the form of commercial fertilizers. The lime is especially low, due to leaching, and must be added to most of these soils for best results.

Some Results With Rotations.—A good example of the effect of rotation on crop production, in comparison with continuous cropping to one crop, is shown in the following data from the Ohio Experiment Station. In the year 1894, two similar fields were laid out in plats. On one field wheat has been grown continuously, a part of the plats with fertilizer and a part without. On the second field, a five-year rotation was laid out, consisting of corn, oats, wheat, clover, and timothy. These plats were repeated, so wheat was harvested every year.

Continuous Vs. Five-Year Rotation With Wheat[1]

System	Treatment	Average annual yield per acre five-year periods. Bushels			Difference first and third periods
		First	Second	Third	
Continuous	Fertilized	19.78	21.90	17.41	−2.4
Rotation	Fertilized	20.53	27.46	33.10	+12.6
Continuous	None	10.8	8.41	6.19	−4.2
Rotation	None	9.28	8.55	13.66	+4.4

In the continuous wheat, the fertilizer was applied every year, while in the rotation, fertilizer was only applied to part of the crops. The average *annual* application was as follows:

System	Acid phosphate, pounds	Muriate of potash, pounds	Nitrate of soda, pounds
Continuous	160	100	160
Rotation	64	52	96

Only about half as much fertilizer was used per year with the rotation crops, but wheat was one of the crops fertilized.

In both cases, yield of crop decreased under continuous cropping, even when heavy fertilizer was added. Yield has slowly increased under rotation farming, even without fertilizer.

Applying Fertilizers.—It has been mentioned several times that nitrogen, phosphates, and potash are the three elements that soils are most likely to be deficient in. When a fertilizer contains the above three elements it is called a *complete* fertilizer. A 2–8–3 fertilizer means that 2 pounds of nitrogen, 8 pounds of available phosphoric

[1] Ohio Experiment Station Bulletin 231, p. 12, 1911.

acid, and 3 pounds of potash are carried per 100 pounds of fertilizer.

Amount of Fertilizer Applied.— No attempt is made to apply enough fertilizer to furnish all the crop needs, as the crop will secure part of its elements from the soil. Nor are the elements applied in the same proportion required by the crop, as the soil is usually most deficient in only one element. Phosphorus is the element most often needed by grain crops. The Indiana Experiment Station recommends a 2–8–4 [2] fertilizer for wheat, in that state, and the following table illustrates the relation between the composition of a 20-bushel crop of wheat and 100 pounds of the fertilizer.[3]

Fertility Removed Compared With That Supplied

	Pounds N (nitrogen)	Pounds P_2O_5 (phosphoric acid)	Pounds K_2O (potash)
Removed			
Grain	20.76	11.52	4.20
Straw	10.32	3.12	17.76
Total	31.08	14.64	21.96
Supplied by 100 pounds 2–8–4 fertilizer	2.00	8.00	4.00
Deficiency	29.08	6.64	17.96

Most cereals require fertilizers rich in phosphoric acid, while root crops and legumes require a higher proportion of potash, and grass crops require nitrogen mostly. The following proportions are typical examples:

Grain crops	2–8–4 to 3–8– 5
Root crops	2–6–6 to 4–8–10
Grass crops	4–6–9 to 9–4– 6

The amount applied varies ordinarily from 100 to 300 pounds per acre. Each farmer must work out the problem by experience on his own land.

Ordinarily, a complete fertilizer is used, but often only a single element, as phosphorus or potash, is all that is needed.

[2] The formula thus given expresses the fertilizers in percentage in the order given in the above table.

[3] Indiana Experiment Station Circular 23, p. 22.

Lime.—A very large proportion of the land in the eastern half of the United States is benefited by lime. This is especially true of the land originally in heavy timber, outside the distinct limestone regions. Usually, from 1000 to 2000 pounds per acre of burnt lime is applied, or its equivalent in hydrated or ground limestone. The equivalents are:

Burnt lime	56 pounds
Hydrated lime	74 pounds
Ground limestone	100 pounds

The lime is best applied with a lime spreader, but is often spread with a shovel. Lime may be applied at any time when there is no crop on the land.

When Fertilizers Are Applied.—Fertilizers are more commonly applied to wheat, potatoes and grass than to other common farm crops. Ordinarily, oats, corn, and clover do not respond sufficiently to fertilizers to pay for direct applications to these crops. Corn, potatoes, and grass make relatively better use of manure than other crops, and the barnyard manure is most profitably applied to these crops.

In a typical rotation consisting of corn, oats, wheat, clover, and timothy for one or more years, the common practice is to apply fertilizer to the wheat, and again fertilizer to the grass, after the first year. If manure is available, the best place to put the manure is on the grass, the last year before breaking up. The grass is thus benefited one year, and the corn crop following is benefited about as much as though the manure were applied directly to this crop.

On wheat, the fertilizer is usually applied at the time wheat is seeded, by means of a wheat drill with fertilizer attachment. On grass, the fertilizer is applied with the same tool, or a regular fertilizer spreader, about two weeks after spring growth starts.

BARNYARD MANURE

Amount Made by Animals and Value.—Professor Roberts, of Cornell, compiled data showing the amount and value of manure made by various farm animals. He estimated the value by charging the price paid for the nitrogen, phosphate, and potash, in commercial fertilizers. However, in addition to the minerals, manure adds

valuable humus to the soil. For convenient comparison, the amount of manure produced is uniformly based on 1000 pounds live weight of the animals.

Manure Per 1000 Pounds of Live Weight[4]

	Excrement per year	Manure and bedding per year	Nitrogen per year	Phosphoric acid per year	Potash per year	Value per year	Value per ton
	Tons	*Tons*	*Pounds*	*Pounds*	*Pounds*	*Dollars*	*Dollars*
Horse	8.9	12.1	153	81	150	42.15	3.48
Cow	13.5	14.6	137	92	140	39.00	2.74
Sheep	6.2	9.6	175	88	133	46.05	4.80
Calf	12.4	14.8	150	105	102	40.35	2.72
Pig	15.3	18.2	331	158	130	80.60	4.43
Fowls	4.3	4.3	293	119	72	68.15	15.85

Nitrogen figured at 20 cents and other constituents at 5 cents per pound.

In regions where farmers raise high-priced truck crops, and buy large amounts of fertilizers, they sometimes pay as high as $2.50 per ton for manure. Add to this the cost of hauling and they pay close to the above estimated value.

When commercial fertilizers alone are used, it is necessary to plow under green crops occasionally to keep up the supply of vegetable matter. With manure alone, the productiveness of land may be kept up indefinitely.

When crops are fed to live stock, about seventy-five per cent of the nitrogen and mineral elements is recovered in the manure.

Many farmers do not care for the manure properly. If manure is leached by rains, or piled up and allowed to heat, more than half the value is readily lost.

Caring for Manure.—The best way to handle manure is to spread it on the land as made. If piled up, care must be exercised to prevent heating, and it should be protected from rains. Some farmers mix a little land plaster with the manure as made, which prevents nitrogen from escaping. Farmers having land that is benefited by the use of phosphate, find it profitable to mix ground phosphate rock or acid phosphate with the manure as made. The usual rate is about 30 to 40 pounds of phosphate rock to a ton of manure. This is an excellent way of applying phosphate to land.

[4] Warren's Elements of Agriculture, p. 139.

QUESTIONS

1. How does rock become productive soil?
2. Where did the organic matter come from?
3. How did soils acquire their nitrogen supply?
4. Why are legumes so important?
5. Why is organic matter so important?
6. What appear to be the direct effects of continuous cropping on a productive soil?
7. Can deterioration be avoided?
8. Explain what is meant by single cropping; alternate cropping; and rotation cropping.
9. Name some good rotations.
10. What factors in productivity does rotation maintain?
11. What does rotation fail to maintain?
12. State in brief results obtained at Ohio Experiment Station.
13. What is a "complete" fertilizer?
14. Does the chemical composition of a crop indicate the kind of fertilizer to apply?
15. Give composition of typical fertilizer mixtures.
16. What are the three forms of agricultural lime and how do they differ?
17. Which crops respond best to fertilizer and which to manure?
18. How is the value of manure made by one animal determined?
19. How much of the plant food is recovered in the manure?

CHAPTER VI

CORN

Where Corn is Produced.—Almost three-fourths of the world's corn crop is produced in the United States, and more than three-fourths in the North American continent, as shown by the following table:

Percentage of World's Corn Crop Produced by Continents[1] *(1906–1910)*

Continent	Percentage of world's crop
North America	78.09
Europe	15.08
South America	4.20
Africa	2.35
Australia	.28

Of the corn produced in North America, less than five per cent of the world's crop is produced in Canada and Mexico, so that the United States, for the period 1906–1910, produced 73.39 per cent of the world's crop.

The Corn Belt.—Seven adjacent states produce more than one-half or, to be exact, 58 per cent of the corn crop. These states are Ohio, Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri. Fig. 15 shows the average distribution of corn for the country.

The two principal reasons for the high production of this crop in the corn belt, are the favorable climate and soil. Corn requires a sunshiny climate and plenty of rainfall. In this region, rainfall is heaviest during the summer months, while, at the same time, there is a large percentage of bright clear days. The land is also level, well-adapted to corn culture, and suited to the use of machinery.

A second reason for so much corn in this region, is that there is no competing crop that farmers cultivate as profitably. In the Gulf States, corn may also be raised at a reasonable cost, but there it must compete with the cotton crop, while in the northeastern states the hay crop is more valuable.

[1] Asia produces a small amount of corn, but no available data.

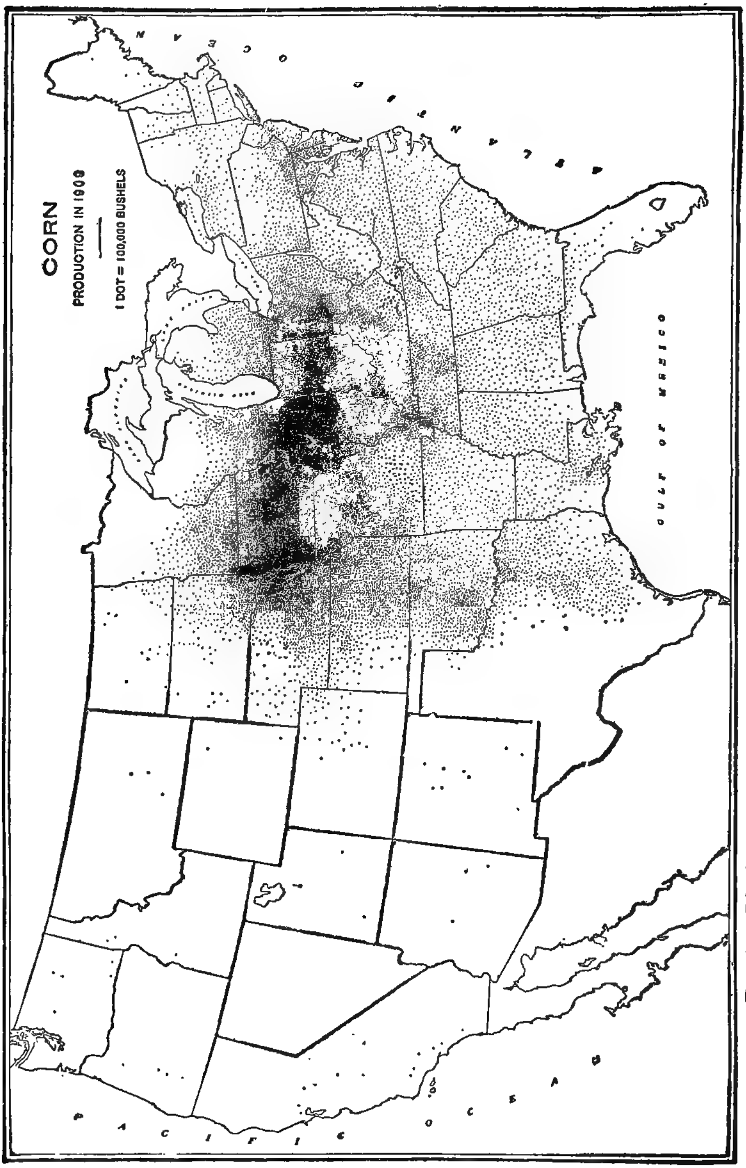

Fig. 15.—Distribution of corn production in the United States. (From the United States Census.)

The Leading Corn States.—The ten leading corn States arranged according to rank are as follows:

Ten Leading Corn Producing States. Average for 5 Years (1906–1910)

State	Production, bushels	Acreage	Value, dollars	Average yield per acre	Average price per bushel
Illinois	355,907,917	9,776,777	160,243,010	34.5	43
Iowa	323,292,400	9,275,400	135,266,400	32.3	39
Missouri	222,421,700	7,401,200	107,606,710	28.6	45
Nebraska	201,315,100	7,421,800	81,986,185	27.4	38
Indiana	174,940,953	4,716,756	79,616,951	34.7	43
Kansas	166,223,800	7,585,800	75,326,000	22.4	42
Texas	145,764,156	6,823,531	87,194,878	19.0	59
Ohio	139,602,600	3,630,200	71,442,910	35.6	48
Oklahoma	111,155,518	5,052,917	50,494,408	24.2	44
Kentucky	93,633,675	3,359,414	50,842,339	26.7	51

The Origin of Corn.—All cultivated plants have been developed from some wild form. The cultivated plants have been selected and changed, so that in many cases they do not bear a close resemblance to the original wild forms. Certain parts of the plant, however, are apt to remain unchanged, so that botanists can determine its close wild relatives.

There are two wild semi-tropical plants similar to corn. These are known as Gama grass (*Tripsacum dactyloides*) and teosinte (*Euchlæna Mexicana*). Both are found growing in Mexico and southern United States. The teosinte will cross with corn, which indicates its close relationship (Fig. 16). Gama grass is more slender than corn, but bears a tassel at the top, resembling a corn tassel. The seeds are borne in the tassel, instead of an ear on the stalk. The teosinte is much more like corn, and bears a kind of branched ear.

There is good evidence that corn was developed by evolution from teosinte or a near relative, and that this origin probably occurred in Central Mexico. From Mexico, it probably spread to South America and North America. When Columbus came to America, corn was in common cultivation throughout both continents. Columbus and other travelers after him carried corn to Europe, where it was called maize and, later, Indian corn.

Fig. 16.—Coyote corn, a form found growing wild in Mexico. Has also been produced artificially by crossing teosinte and corn. (U. S. Department of Agriculture.)

The word corn is used in Europe for all cereals, as wheat and barley, and the name "Indian corn" serves to distinguish maize from the other grains. In the United States, the name corn is correct and has attained legal standing.

Classification of Corn.—There are six principal types of corn. These types are pop-corn, flint corn, dent corn, soft corn, sweet corn, and pod corn (Figs. 17 and 18). The classification is based principally on the character of the kernel. Pop-corn is very hard and flinty in character; the flint corn kernel is similar, but larger, and contains some soft starch in the center; the dent corn kernel is about one-half hard and one-half soft starch, while the soft corn is entirely soft starch. Of course, there are intermediate stages between each class, so that practically a perfect series is found, from the hard, flinty pop-corn to the soft, flour corn. Growers, however, have usually selected those named above for the distinct types, so there are not many of the intermediate kinds in cultivation.

Sweet corn and pod corn may be variations from any of the above four types. Sweet corn is any kind that lacks the factor for converting its sugars to starches, so it stores its kernels with sugar-like compounds. The pod corn may be any of the

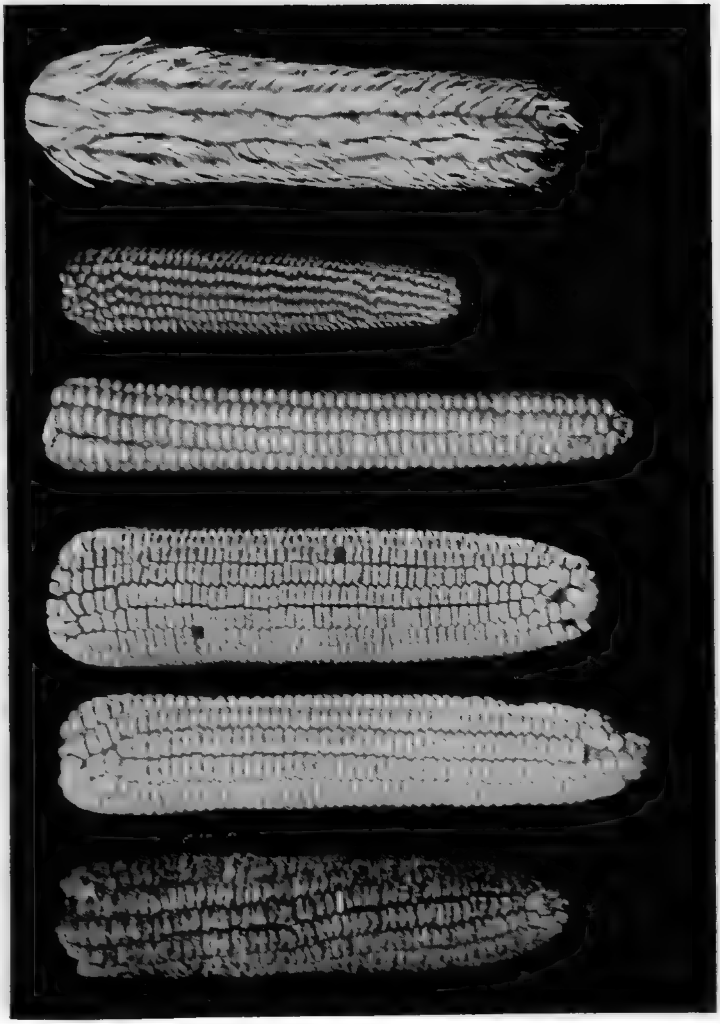

Fig. 17.—Six principal types of corn. From left to right, pod corn, pop-corn, flint corn, dent corn, flour corn, and sweet corn. (From Corn Crops by Macmillan Publishing Co.)

FIG. 18.—Kernels of principal types of corn. Top row, left to right, flint corn, flour corn, pop-corn. Bottom row, sweet corn, dent corn, pod corn

above varieties, with a tendency to develop the small scales at the base of each kernel into large size.

The relationship of the six types may be illustrated by the following:

1. All hard starch—pop-corn
2. All hard but center—flint corn
3. Crown of soft starch—dent corn
4. All soft starch—soft corn
5. Sweet corn, any kind that does not develop starch.
6. Pod corn, any kind that develops glumes or "pods."

Pop-corn (Zea Mays everta).—Very hard corneous endosperm; kernels small. Popping quality due to the explosion of moisture on the application of heat. The kernel is so hard that the moisture is retained until it reaches high temperature. There are two types of pop-corn known as rice corn, with pointed kernels, and pearl pop-corn, with round kernels. All common colors and size of ears vary from 2 to 7 inches in length. Rows 8 to 16. Tom Thumb pop-corn is the smallest variety of corn grown.

Flint Corn (Zea Mays indurata).—Horny outside, and soft starch in center. Kernels usually rounded, though some varieties have short flat grains. Flint corn is adapted to cooler climates and higher altitudes than dent corn and is therefore the principal variety of corn in climates too cool for dent corn. Length of ear varies from 6 to 14 inches; rows 6 to 14; all colors.

Dent Corn (Zea Mays indentata).—Horny starch on sides and soft starch in center. The soft starch shrinks in drying, thus giving the dent. The plant varies in height from 5 to 18 feet, the ear varies in length from 6 to 12 inches, and has 8 to 24 rows. Practically the only type cultivated in the corn belt.

Soft Corn (Zea Mays amylacea).—Sometimes called flour corn. Endosperm composed of all soft starch. Kernels shaped like flint corn; all colors, but white and blue most common. Ears are 6 to 10 inches in length and mostly 8- to 12-rowed.

Sweet Corn (Zea Mays saccharata).—Translucent, horny and wrinkled kernels. Sweet corn develops very little or no starch, apparently being any type of corn lacking the factor for converting its sugars into starch. Has sweeter taste than other corns.

Other types of corn, but much more rare, are Coyote corn (*Zea Mays canina*), *Zea Mays japonica,* a variety with striped leaf; *Zea*

Mays hirta, leaves and stem covered with hairs; *Zea Mays curagua,* a form having a serrate leaf; and Chinese maize, a form having a waxy instead of a starchy endosperm.

Number of Varieties.—In 1898, Professor E. L. Sturtevant published a description of 507 varieties, though he thought that in many cases the same variety had more than one name, there being 163 synonyms. He classified the varieties into the following natural groups:

Dent corns	323 varieties
Flint corns	69 varieties
Sweet corns	63 varieties
Soft corns	27 varieties
Pop-corns	25 varieties

Growth and Development of Parts.—If a young plant six inches high is taken up and examined, it will be found that all the principal parts of the plant have begun development. Cut the plant in two lengthwise. In the center is a short stem. Note that the stem is divided by nodes very close together. While the stem at this stage may not be more than one or two inches long, some 12 to 20 cross nodes (or the full number when mature) may be made out by careful examination.

From the very lowest nodes on the base of the stem, roots have been thrown out. From the upper nodes leaves are developing. The full number of leaves may be counted at this time. At the very tip of the little stem, an embryonic tassel can be seen. Inside each leaf may be seen a very small bud. Note that all parts of the plant, roots, leaves, buds, arise from the nodes. Now as the plant grows, the stem between the nodes (internodes) simply lengthens, stretching out the entire length of the stem like a telescope. At the same time all parts of the plant grow in size, but no *new* parts are formed.

When the plant has attained some size, one or two of the buds near the base of the stem may begin very rapid growth and develop into tillers or suckers. A little later one of the buds from near the middle of the plant will develop into an ear.

The stem is divided by nodes. The number of nodes varies with the height of plant. In northern latitudes the number above ground is about 10 and the height of stalk 6 feet, while in the south, plants 12 to 15 feet high have 18 to 20 nodes, and a corresponding number of leaves in each case.

Tillers or suckers come from buds developed at the surface of the soil. If conditions are unfavorable, these buds may simply remain dormant, but if the soil is rich, or planting thin, one or more may develop. Some varieties naturally produce more tillers than others. Sweet corns and flint corns produce more tillers than dent varieties.

The Roots.—When a seed of corn germinates a few temporary roots are first developed. These do not grow very large and appear to function only while the young plant is establishing. When the young plant reaches sunlight with its leaves, it begins at about the same time to develop permanent roots. These are thrown out at the base of the stem, which usually forms at about one inch below the soil surface. No matter at what depth the seed was planted the permanent roots develop at about the same depth below the surface.

Spread of Roots.—Corn roots usually spread out laterally when full grown to a distance of four to six feet on every side of the plant, and downward to a depth of five feet on friable loam soils; but on heavy clay or hardpan soils they may penetrate only two feet. Most of the roots are in the upper 12 to 18 inches, this portion of the soil in a corn field being thoroughly filled with roots. The upper roots are usually about three inches below the surface in loose prairie soils, but in a close clay soil they may come within one inch of the surface, necessitating very shallow cultivation.

Brace roots are strong roots thrown out just above the soil surface. Above ground they are strong and rigid, but entering the soil they become small and branching, and function like other roots. As the name implies, their principal function is to brace the plant against the effect of strong winds.

Tassel and Ear.—The corn tassel produces the pollen for fertilizing the ears. The tassel branches bear a great number of pollen sacs, each of which is filled with pollen grains. It has been estimated that one tassel bears twenty million pollen grains. When the silks are ready to be fertilized, the pollen sacs begin to open and shed the pollen. Not all the pollen from a tassel is shed in one day, but from day to day for about one week. The pollen grains are easily carried by wind to the corn silks (Fig. 19).

The Ear.—An ear of corn usually has from 500 to 1000 kernels. The number of rows varies from 8 to 30. The cob and kernels de-

velop until about one-fourth full size, then each kernel sends out a long silk or style. Those kernels near the butt send out silks first, then silking gradually proceeds toward the tip; the whole process taking from two to three days. As soon as a silk emerges from the husk it is ready to receive pollen. One pollen grain must fall on

FIG. 19.—Ear of corn in full silk, and ready to be fertilized. There is a silk (pistil) from each kernel, and each must receive a pollen grain.

every silk, for if it does not receive pollen, the kernel to which it is attached will not develop.

Fertilization.—When the pollen grain falls on a silk, soon a small tube is sent out which finds its way down the silk and into the egg cell of the young kernel. Reaching the egg cell, the contents of

the pollen grain unites with the egg cell, and very soon growth begins.

Hybridizing.—When the pollen comes from another variety or type of corn, the ear produced is then said to be "crossed," or is a hybrid ear. All kinds of corn will cross naturally if planted near enough for pollen to be carried by the wind (Fig. 21).

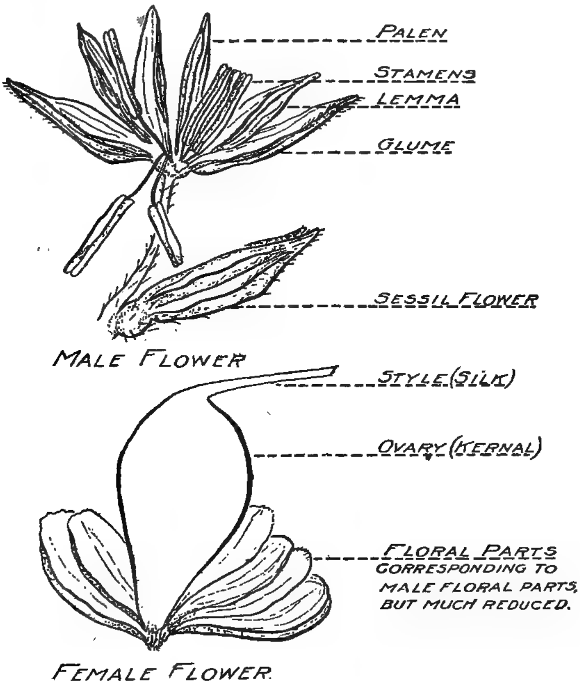

Fig. 20.—Method of preparing a laboratory exercise, and also showing in detail the male (from tassel) and female (from ear) flowers of corn.

Crossing is often done artificially. The ears and tassels of plants to be crossed are first covered with paper bags (Fig. 21), before the silks have appeared or pollen is shed. In a few days, when the silks have appeared, pollen is taken from another plant and applied to the silks.

The Effects of Hybridizing.—When two varieties of corn are hybridized or crossed there is some direct effect seen the first year,

though most of the effect is seen the next year in the plants grown from the hybrid seed.

If a sweet corn ear be fertilized by pollen from a dent corn plant, a large proportion of the sweet corn kernels crossed will be smooth, like a dent corn, though not all the crossed kernels are so affected.

The second year, however, if the kernels are planted, the ears produced will be mixed sweet and dent. Plant all the kernels pro-

Fig. 21.—Corn plant prepared for artificial crossing. The tassels are covered with sacs to catch pollen, while the ears are protected.

duced by this first generation, and in the second generation it will be found that one-fourth of the ears produced are pure sweet corn and will come true afterward with no sign of the dent. One-fourth of the ears will be true dent that will come true afterward, but one-half the ears will again be hybrids. This rule applies to a great many plants and is called Mendel's law, after the man who discovered it.

The effect of crossing on the vigor and yield is very marked also (Fig. 22). When the seed has been fertilized by pollen from the

same plant, it usually produces smaller plants and poor ears. The yield is usually reduced about one-half by inbreeding, as it is called.

Fig. 22.—Effect of crossing and self-fertilization on vigor of plants. (1) cross-fertilized; (2) close-fertilized, *i. e.*, from related plant; (3) self-fertilized, *i.e.*, from own pollen. These are typical plants after three years in each case. (From Corn Crops, by Macmillan Pub. Co.)

When the pollen comes from an unrelated plant the vigor and yield of the crop from this crossed seed is increased.

In nature most of the corn is pollenized by other than its own pollen, but at least some kernels must be self-fertilized on each ear.

These self-fertilized kernels probably account for many of the small or barren stalks in fields. It has often been found to increase the yield to cross two varieties, as illustrated by the following data taken from the Illinois Experiment Station. The table gives the yield of the two parent varieties and then the yield of the hybrid of these varieties.

Yields from Crossing

Variety	Bushels per acre of corn
Burrs White	64.2
Cranberry	61.6
Average	62.9
Cross	67.1
Burrs White	64.2
Helm's Improved	79.2
Average	71.7
Cross	73.1
Burrs White	64.2
Edmonds	58.4
Average	61.3
Cross	78.5
Leaming	73.6
Golden Beauty	65.1
Average	69.3
Cross	86.2
Champion White Pearl	60.6
Leaming	73.6
Average	67.1
Cross	76.2

QUESTIONS

1. Where is the "corn belt" and why is so much corn grown here?
2. Where was corn first grown?
3. Does it have wild relatives?
4. Name and distinguish the six principal types of corn.
5. What type is most important?
6. What conditions affect the production of tillers?
7. Does depth of planting affect depth of permanent roots?
8. How are roots distributed in the soil?
9. What is pollen? How does it fertilize the ear?
10. What part of the ear silks first?
11. Explain hybridizing.
12. What effects are noted from hybridizing, on the kernels? On the vigor of plant?

CHAPTER VII

CLIMATE AND SOIL REQUIRED FOR CORN

Effect of Climate.—Corn is of tropical origin, but, owing to its ready adaptation, it has been adapted to grow and mature as far north as southern Canada. However, corn has not lost its liking for warm, sunshiny weather. Corn not only requires warm days but comparatively warm nights as well. One effect of cool nights, even when the days are warm, is to delay ripening. This effect is best seen at high elevations where the nights are cool.

In the Middle States corn that will mature in 100 days at an elevation of 1000 feet will require 130 to 140 days at elevations of 2000 or 3000 feet.

Flint corns will mature in cooler climates than dent corns. In Mexico dent corn will mature at elevations of 8000 feet, but in North Carolina only from 2000 to 3000 feet; and as far north as New York, only the very earliest varieties will mature at 1000 feet elevation. Flint corns, however, will do well at 1000 feet in New York, and much higher. Consequently, in this State and all New England most of the corn raised is flint, except for silage when it is cut green.

Sunshine is also required, and in some places where it is cloudy for half the time, corn does not do well on that account. While hot, sunshiny days are not always the most agreeable, yet this kind of weather is the greatest asset of the corn- and grain-growing belt in the Central States.

Soils for Corn.—Corn is sometimes called a "coarse feeder," owing to its ability to apparently use coarse manures, and will thrive on new clover sods, in contrast with wheat and oats which are said to be "delicate" feeders, as they require the manure and sod to be thoroughly decayed for best results.

Corn does well on land very rich in nitrogen, while small grain would lodge on such a soil. Land can hardly be made too rich for corn. The best natural corn lands are the rich black river bottoms

of the Mississippi River basin. There is no better place to plant corn than on a heavy clover or alfalfa sod, or after a crop of cow peas has been plowed under.

A heavy clay soil, such as would produce good timothy, is not the best soil for corn, and, on the other hand, a sandy potato soil is too light for best results with corn, unless heavily manured. A medium loam, well drained, is considered as ideal land for corn. The land must be comparatively easy to prepare and cultivate for profitable corn culture, as corn is an extensive crop rather than an intensive crop, and culture must be relatively cheap.

Length of Growing Season.—Corn varies in the time required to ripen from 200 days down to 90 days for the earliest varieties. The length of growing season is defined as the average time between killing frosts from spring to fall. However, as some seasons have very late spring and very early fall frosts, the farmer usually selects a variety of corn that will mature in the shortest season likely to occur.

It will take about 150 days to mature the large, most productive types of corn, which is about the season available in the latitude of Central Missouri or the lower Ohio River. North of this the shorter growing season is a limiting factor in the yield of corn.

Rainfall.—A heavy crop of corn requires a very large amount of water during a comparatively short time. This short period is about six weeks in July and August. From 18 to 20 tons of water are required to pass through the plants to produce one bushel of corn. Also considerable water is lost by runoff when heavy rains come and by evaporation from the soil.

It is very important that plenty of rain falls during the growing season of June, July, and August. Records show that the average yield of corn in the corn belt varies from year to year with the average rainfall for these three months. The crop is good with 12 to 14 inches of rain for the period, and poor when the rain amounts to only 8 or 10 inches.

Importance of Adaptation.—While there is a certain ideal kind of corn climate and soil, yet corn has been adapted to a wide range of conditions, as high elevations, dry climates, humid climates, clay, and sandy soils.

It is reasonable to expect that a corn that has been adapted to a certain set of conditions will do better under those conditions than some variety from a distance. This fact has been demonstrated many times by farmers and experiment stations. For example: In eastern Nebraska the rainfall is about 30 inches, while in the western part of the state it is about eighteen inches, and the elevation is about 2000 feet higher. An experiment was tried for two years in western Nebraska. Farmers grew in the same field a number of varieties mostly from eastern Nebraska in comparison with varieties grown in western Nebraska, with the following results in yield of bushels per acre [1]:

Influence of Adaptation

Year	Varieties mostly from eastern Nebraska	Native western varieties	Difference in yield
1908	24.1	30.5	6.4
1909	20.9	25.4	4.5
Average	22.5	27.9	5.4

The importance of using native-grown seed has been demonstrated many times in other states.

QUESTIONS

1. What effect do cool nights have on maturing of corn?
2. Do dent and flint corns differ in adaptation to climate?
3. Describe a good corn soil.
4. How long should the growing season be for good corn?
5. How much water is required to make a bushel of corn?
6. How much rain is needed for a good crop?
7. Explain the importance of adaptation or acclimated corn.

[1] Nebraska Agricultural Experiment Station Bulletin 126, 1912.

CHAPTER VIII

CORN CULTURE

Selecting a Variety.—In the Gulf States "prolific varieties" are grown mostly, which means varieties normally producing more than one ear on a stalk (Fig. 23). North of the Ohio River only single-ear varieties are grown. Between the Ohio River and the Gulf States is an intermediate territory where both kinds are grown.

The varieties in the corn belt and southward are practically all dent corns, but north of the corn belt and at high elevations flint varieties are grown mostly. Flint corns will mature in cooler climates.

Some of the well-known prolific varieties are Mosby, Blount, Cocke's Prolific, Sanders, Albemarle, and Marlboro.

The most important large white dent varieties are Boone County White, St. Charles White, Silver Mine; and the most important large yellow varieties are Leaming, Riley's Favorite, Reid's Yellow Dent, and Legal Tender.

The best known early dent varieties are Pride of the North, White Cap, Minnesota No. 13, Wisconsin No. 7, Early Huron, and Early Calico.

Well-known flint varieties are King Philip, Sanford White, Smut Nose, Gold Nugget, Eight-row, and Twelve-row yellow flints.

There are probably more than 1000 varieties of corn, but the few varieties named (and varieties derived from them) constitute a very large percentage of the corn raised. Leaming and Silver Mine are probably raised most extensively.

There are many varieties thoroughly adapted to certain conditions, and farmers should always investigate local varieties first (Fig. 24). It has already been pointed out (Chapter VII) that thoroughly adapted corn is better than corn from a distance. The only exception to this rule is in the case of corn grown for fodder or silage north of the corn belt. Since silage is sometimes cut green, the corn need not mature, and a large, late variety will often produce more feed than one that would mature.

IMPROVEMENT AND BREEDING OF CORN

Varieties.—Where did all the varieties come from? There are hundreds of varieties. A little study into the history of any particular variety will generally show that back somewhere a careful grower spent years in selecting and improving the variety. He always had some ideal in mind, and going into his corn field endeavored to find ears representing this ideal. Perhaps he tried to develop a 12-rowed flint instead of an 8-rowed, or desired some different shape of ear or kernel. By careful and patient selection toward his ideal he would finally develop a variety having the desired character. Some man spent 10 to 40 years to fully develop and fix the type. Such a variety is Reid's Yellow Dent. Mr. James Reid began selecting this in 1846, but it was not until 50 years later that it came into general cultivation.

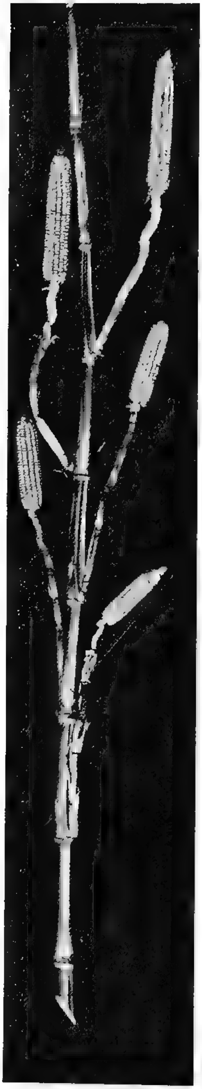

Fig. 23.—Stalk of prolific corn, leaves removed to show ears. A common type in southern states. (From Tennessee Experiment Station.)

Ear-to-row Breeding.—About 1895 general attention was first called to the plan of corn improvement which we now know as "ear-to-row" breeding. It was found that many ears of corn would yield unusually high, but this could not be told by examining the ear. The new plan was to plant each ear to a row, then in the fall select seed only from those rows giving a high average yield. This method is superior to the old method of merely selecting the best looking ears (Fig. 25).

Crossing.—We have already noted the effect of crossing on corn. New varieties can easily be produced by crossing, and it is sometimes desirable to cross varieties for this purpose. In fact, many of the variations found in corn fields are due to natural crossing, which is commonly due to the great distance pollen is carried by wind.

SELECTION AND CARE OF SEED CORN

The careful selection of seed corn seems important for two reasons: (1) In practically all the region north of the Ohio River it is necessary to see that corn matures well, while at the same time maintaining the size of the ear. (2) Since corn plants are spaced wide apart (as compared with small grain which is sown thickly), the plants are largely relieved from the effects of "natural selection,"

FIG. 24.—Difference in types of corn. Eureka corn, a southern type, compared with sweet corn on right.

and so "artificial selection" must be practised to maintain the crop. Natural selection can be secured by very thick planting, and results at the Nebraska Station indicate that a more vigorous type of corn can be developed under thick planting than under thin planting. For several years corn was grown continuously, in one case, with only 1 stalk per hill; in another case 3 stalks per hill were grown

FIG 25.—Two types of Leaming corn developed by six years' selection at the Illinois Experiment Station, the one for low ears and the other for high ears. (From Illinois Experiment Station.)

continuously; and in a third case 5 stalks per hill were grown. In the thick planting only the strongest stalks could produce good ears. The yields produced in 1911, after six years of natural selection, when seed from each case was planted at the normal rate (3 stalks per hill), were as follows [2]:

Results from Seed Selected from Thick and Thin Plantings

Origin of seed	Yield when planted 3 grains per hill. Bushels per acre
One plant per hill	39.8
Three plants per hill	43.7
Five plants per hill	48.1

Selecting Seed from Crib.—In the past common custom has been to husk the corn crop and crib the ears. The farmer would select his seed while the corn was being cribbed or taken out. Often excellent seed corn can be secured in this way, but there are at least two disadvantages: (1) The crib is not a good place to preserve the germinating qualities of corn, and often it is difficult to find seed that will grow. (2) It is not known under what conditions the seed corn was grown. There are always very favorable places in the field where it may also happen that the stand of corn is thin. Large ears may grow here, but they are not necessarily adapted to the average conditions of the field.

The best seed corn is that grown where the stand is normal and the soil conditions are average.

Field Selection.—Many good growers now select their seed corn from the standing stalks in the field. Where it is desired to maintain or increase the earliness of the corn, selection is usually made as soon as the first ears are well matured. In the corn belt this would be about the last of October.

The advantages of field selection are: (1) Early maturing ears may be selected. (2) The conditions, as to soil and stand, under which the plant was grown may be known. (3) Character of the plant may be known. It is desirable to select ears of uniform height and growing rather low on the stalk. (4) The seed corn may be carefully dried and stored to preserve germination.

Storing Seed Corn.—All the factors that cause seed corn to lose germination have not been clearly worked out. Corn when first ripe

[2] Nebraska Agricultural Experiment Station Bulletin 127, p. 21, 1912.

contains 25 to 30 per cent of water, while good dry corn contains only 10 to 12 per cent of water. If the ear corn does not dry down rapidly (in three or four weeks) it is very apt to lose in germinating quality. Freezing is especially injurious when corn is damp, but it will deteriorate without freezing. When corn is dry (15 per cent moisture) it will endure hard freezing without injury, and retain germination for several years.

Therefore, the most important matter to be given attention is to dry the seed corn as soon as ripe. In large seed houses the corn is sometimes kiln-dried by artificial heat, but the farmer will ordinarily dry his seed by hanging on strings, impaling the ears on nails driven into a board, laying them on shelves made from wire netting, or by use of one of the many drying racks on the market.

Drying will take three to four weeks, when the ears may be packed in crates or shelled to be stored in a dry loft.

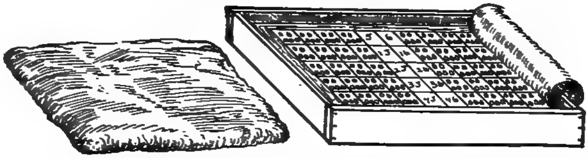

FIG. 26.—A box tester for seed corn. Upon muslin cloth squares are drawn and numbered. On each square are laid five kernels from an ear of the same number. When the tester is filled, the sawdust pad shown at the left is placed to keep the grain moist. (Davis's "Productive Farming.")

Examining Seed Corn.—To determine by examination whether seed corn will grow, first make a careful study of good, bright, sound corn that is known to grow well. Know in particular how a good germ looks when cut open with a sharp knife. Note that the germ is neither brittle nor very soft, but cuts about like solid cheese. Then this rule may be accepted: *Any discoloration of either the grain or any part of the germ, or any departure from normal texture, indicates weakened vitality.* A careful man may discard most poor germinating ears by examination.

Germination Tests.—There are occasions when enough good, sound ears are found only with difficulty, and it is necessary to take a great many ears of doubtful germinating qualities.

First take a random sample of 100 ears and, taking 3 kernels from each, make a general test. If less than 90 per cent of the kernels produce good sprouts, it would then be advisable to test each ear sepa-

rately. This can be done by preparing a number of large germination boxes.

Germination Box.—Make a box of wood or sheet-iron about 30 inches square (Fig. 26). Put 3 inches of sand or sawdust in the bottom. Lay over this a white cotton cloth marked off in 3-inch squares. Number the squares from 1 to 100. Now place the ears of corn in order, on a floor, shelves, or in a rack. Number the ears from 1 to 100. Place six grains from ear number 1 in square number 1, and so on until grains have been taken from each ear. Lay a second cloth over the kernels and place one inch of sawdust on top. Wet down thoroughly and keep in a warm place. In 5 days the top cloth can be rolled off, and examination will readily show which ears will germinate and which will not.

There are a number of patented germinators on the market, with means of providing artificial heat, that are satisfactory.

Doll Baby Germinator.—Another satisfactory method is the doll baby. Lay out the corn ears side by side on a floor. Lay a long strip of Canton flannel 12 inches wide by the row of ears. Place kernels of corn about three inches from one edge of the cloth strip. Then fold over the strip from one side. Roll strip from one end. When rolled up, soak in water for 12 hours, then place roll in a covered receptacle and keep at proper temperature for several days. Unroll cloth at end of same ears of corn. At a glance it will be ascertained which ears will grow.

Butt and Tip Kernels for Seed.—Frequent tests have shown that butt and tip kernels grow and produce fairly well. However, they are smaller, and planters can not be adjusted to plant all sizes of corn evenly. It is advisable to remove the small kernels from butt and tip before shelling seed.

EXERCISES

Field Study of Maize.—This exercise is most valuable if made in two fields, one a good field and the other poorer.

1. First measure the width of rows and figure out how long a row it will take to equal one one-hundredth of an acre. In most fields this will be between 7 and 8 rods.

2. Let each student take a row and secure the following data:

How many stalks per row?
Per cent of ear-bearing stalks.
Per cent of barren stalks.

How many stalks per acre?

Weigh three ears of dry corn, representing small, medium, and large ears.

How many bushels per acre if each stalk produced an ear? Figure for all three sizes (70 pounds ears per bushel).

Use following form to report:

Weight of ears	Number of ears per acre	Bushels per acre	Per cent barren plants	Reduction in yield due to barren plants

Selecting Seed Corn.—Class select 100 seed ears, and divide into four lots. Store each lot in a different place, selecting at least one good, dry, airy place, and one place where corn will dry poorly, as a tight barrel or box. Later make germination tests to determine effect of storage on yield.

If apparatus is available, it will be well to determine moisture present when gathered, and twice a month while drying.

Study of Germinating Quality of Corn.—The purpose of this exercise is to acquaint the student with the characteristic appearance of good and poor kernels of seed corn, with special reference to germinating qualities.

Preparing Germination Box.—A box 15 inches square and 3 inches deep will germinate 25 ears.

1. Put 2 inches of sawdust in box and tamp down well with a brick.
2. Lay on the sawdust a piece of blotting paper or white cloth which has previously been marked into 3-inch squares.
3. Number 25 ears of corn.
4. Take from each ear 6 kernels from near the butt, middle, and tip, and place in germinator. Examine two or three more kernels by cutting open with a sharp knife.
5. Mark a piece of note paper into 25 squares and fill out in corresponding squares the following data on each ear. This is to give you an opportunity to make a detailed study.

A. Grain:

1. Appearance—bright; dull?
2. Discolored—back; tip?
3. Shape of tip—pointed; plump?
4. General texture—hard; soft?

B. Germs:

5. Covering—smooth; blistered?
6. Texture—soft; medium; dry?
7. Air-space—large; small; none?
8. Color—normal; yellowish; etc.?

6. On a second sheet state your opinion on germinating quality and also data secured.

1. How do you expect this to germinate—good, medium, poor?
2. Number germinated 6 days?
3. Number germinated 10 days?
4. Is germination strong, medium, weak?

7. *Written Conclusions.*—From results of your test and information from readings and lectures, make a report.

1. Number of ears showing strong, medium, and weak germination.
2. Designate the 5 best ears.
3. How should seed corn be selected and preserved to secure best germinating qualities?

1	
2	
3	
4	
5	
6	
7	
8	

The above is the way sheet is ruled for making out reports on ears.

QUESTIONS

1. How do varieties differ in the Gulf States, the corn belt, and the northern States?
2. How have varieties of corn originated?
3. Explain ear-to-row breeding.
4. Does corn always mature well?
5. Explain the principle of "natural selection" in growing seed corn.
6. Explain disadvantages of crib selection of seed.
7. Explain advantages of field selection.
8. What are the principal precautions to observe in storing seed corn?
9. Describe the appearance of good seed corn.
10 How do you make germination test in a box? by the rag-doll method?
11. Compare the value of butt and tip kernels for seed.

CHAPTER IX

PREPARATION OF LAND FOR CORN

UNDER the chapters discussing "Soil for Corn" and "Cropping Systems" attempt has been made to show how land can best be maintained in a productive state for corn production. It takes years to "run down" or make unproductive a good piece of land by even the most exhaustive cropping method. It takes even longer to restore production to an exhausted field. The important consideration in crop production is maintaining the productivity of the land.

Preparation, Secondary.—The crop depends not so much on the preparation just preceding planting (provided it is reasonably good) as it does on the treatment the land has had for the previous ten or twenty years.

To thoroughly plow, pulverize, and free from weeds is all the preparation good land needs.

Plowing Corn Land.—Experiments have not shown an exact relationship between depth or time of plowing and yield. This is probably because the temporary effect of deep or shallow plowing may be very small, owing to other more important factors, and also because results appear to vary some with soils and seasons.

In the rather loose loam soils of the semi-arid regions at the west edge of the corn belt, in central Kansas and Nebraska, more than one-half of the corn land is not plowed at all. The land may be disk-harrowed in early spring, to preserve moisture, and perhaps again just before planting to kill weeds. The corn is planted with a lister, which is a double mould-board plow that opens up a furrow, planting the corn in the bottom.

In the South corn is also planted in a furrow, on the drier sandy lands. The "listing" method then is confined to the loose, drier soils in the West and South. In all other places the land is prepared by plowing.

The reason seems to be that practically all heavy land in humid

seasons must be plowed thoroughly once a year to keep it in good physical condition, while in cultivated crops. Without good plowing the land becomes hard, and increases the labor of planting and cultivating.

Depth of Plowing.—Nothing definite can be said regarding depth of plowing so far as immediate effect on the corn crop following. However, common experience is that land can not be kept in a good productive state by constant shallow plowing. The reasons seem to be: (1) The humus and fertilizer applied is then limited to the surface few inches. (2) The benefits to be derived from the humus or fertilizer can not be fully utilized by the plant, as it does not have sufficient roots in the surface three or four inches; also the surface may be too dry for considerable periods. (3) Constant shallow plowing is apt to give a hardpan subsurface.

Fall or Spring Plowing.—Where heavy sod lands are to be put into corn or manure is to be turned under, fall plowing is best, as the vegetable matter decays more thoroughly. In other cases where the corn follows corn or grain, fall and spring plowing give about equal results. It is then largely a question of farm management. On most farms it is convenient to do a part or all of the plowing in the fall.

On some heavy soils the fall-plowed land becomes too compact by spring, necessitating replowing for the corn. In such cases spring plowing is cheaper and advisable.

Time of Spring Plowing.—Three advantages have been established regarding early spring plowing as compared with late spring plowing: (1) The available plant food, especially nitrogen, will be greater with early plowing, due to aëration and greater activity of soil bacteria. (2) More moisture will be conserved, if the spring is dry. (3) As a result the yield of corn is usually better.

Preparation After Plowing.—The principal objects of preparation after plowing are to pulverize and compact the soil well and destroy weeds.

Caution is needed in the case of certain very fine clay soils, which when pulverized too fine are apt to run together in a hard crust after heavy rains. On such soils tools that give a coarse preparation, such

as cultivators or spring-tooth harrows, should be used rather than the disk harrow.

It is all-important to kill weeds before planting, as it greatly simplifies the care of the crop. One advantage of early plowing is that weed seeds may be germinated and destroyed before planting.

PLANTING CORN

As heretofore stated, corn is planted in furrows on light dry soils; on the level surface generally, and also on ridges in certain wet lands in the southern States. Corn may be drilled, or check-rowed, *i.e.*, in hills rowing both ways. It is dropped by hand, with various kinds of one-horse drills, and with two-horse planters.

Hand Planting.—In regions where the average planting per farmer is ten acres or less, the planting is quite generally done by hand. Either the prepared land is furrowed out both ways and the seed dropped at the intersecting furrows, or it is planted with a hand jab planter. A man can plant 5 acres a day by hand. The depreciation, repairs, and interest on a $40 machine would amount to five or six dollars per year, so that hand planting on small areas is really cheaper than keeping a two-horse machine.

Drilling.—Many farmers growing small areas of corn use a one-horse drill, partly because it can be bought much cheaper than a two-horse check-row planter. A grain drill can also be easily adapted to drilling corn by stopping up part of the feed holes. This tool is used very generally throughout the North Atlantic States for drilling silage corn.

Drilling has another advantage on hilly land in following the contour of the hills with rows, thus preventing soil washing.

Check-row Planting.—On level land where large fields are grown, check-row planting is the common method. This is principally because it is easier to keep free from weeds. Drilling on the surface makes necessary either hand hoeing to keep weeds out of the row, or throwing considerable soil to the corn in cultivating in order to cover the weeds. This latter method develops too much of a ridge.

Listing.—When corn is planted in a furrow, as with the lister

(p. 67), it is drilled. The soil can all be thrown back to the corn in cultivating, covering weeds and finally leaving the land level.

Furrow openers, consisting of a pair of disks, are now put on regular two-row surface planters. These open a shallow furrow, and the corn may be either drilled or checked.

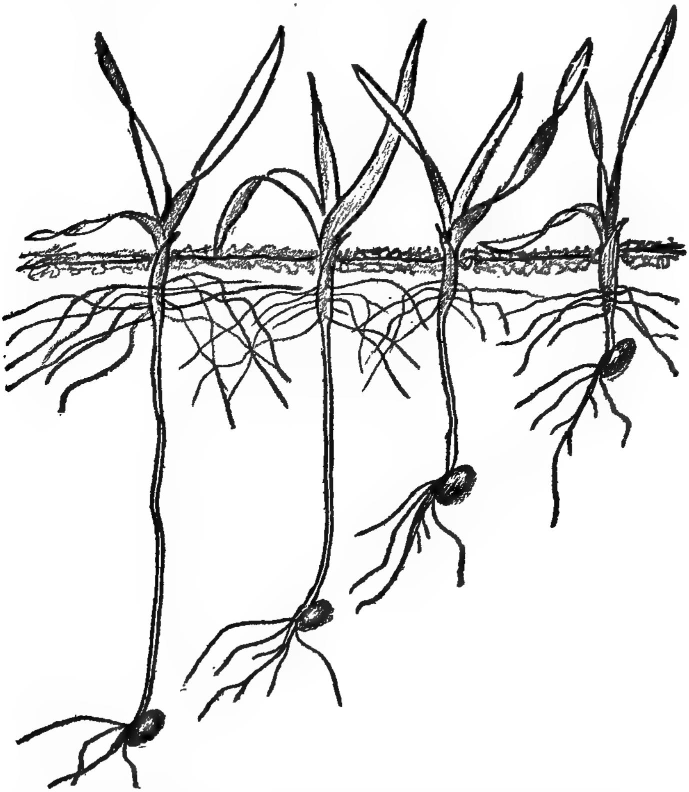

FIG. 27.—Wheat plants illustrating the principle that permanent roots always develop at about the same depth, whether the seed is planted deep or shallow.

Yield of Hill and Drill Planting.—At the Illinois Station the two methods of distributing seed were compared in this way: Corn was planted one plant every 12 inches, two plants every 24 inches, three plants every 36 inches, and four plants every 48 inches. No marked difference was found in yield of grain per acre, so long as the number of plants per acre was the same.

Time of Planting.—The following table shows the time of planting in the United States[1]:

Time of Planting Corn

Region	Beginning	General	Ending	Planting period, days
Gulf States	March 15	April 5	May 10	55
Central States (Virginia to Kansas)	April 15	May 1	May 25	40
Northern States (New York to Minnesota	May 10	May 20	June 1	20

The planting period is much longer in the southern States than in the North.

Experiments have shown that the very earliest or latest plantings in any particular region do not give as good yields as intermediate plantings. The Illinois Station made a number of plantings from April 28 to June 9. The corn planted in May averaged 73 bushels per acre, while the remaining plantings, one in April and two in June, yielded only 63 bushels per acre.

Depth of Planting.—There is no object in planting corn deeper than is necessary to insure good germination. Experiments in a number of States with corn planted from one to six inches deep, have seldom shown advantage for the very deep plantings. In heavy, cold or wet soils from one to two inches is best, while in lighter and dry soils two to three inches is best.

Some have thought that the corn would root deeper if planted deep. The plant, however, usually forms its first joint about one inch below the surface, no matter what the depth of planting, and the roots are developed from that point (Fig. 27).

Rate of Planting.—The customary rate of planting varies from 3000 to 4000 plants per acre in the Gulf States to 12,000 to 15,000 in the northern States. The plants are larger in the South and the soil is often poor, but the size of plants decreases to the north and the customary rate of planting correspondingly increases. The following table illustrates:

[1] U. S. Yearbook, 1910, p. 491.

Customary Rate of Planting Corn

Region	Distance apart of hills	Plants per hill	Plants per acre
Gulf States	4′ x 5′	2	4,000
Middle States	3′8″ x 3′8″	2–3	9,000
Northern States	3′6″ x 3′6″	3–4	12,000

There is a wide range of planting in any region, within which there will be very little effect on yield of grain, although the yield of stover will usually increase with rate of planting. This is due to the *adjustment* of the plants. With thick planting the ears are smaller, while more plants are barren. The following data show yields at the Nebraska Station for different rates of planting:

Results with Planting Corn at Various Rates (1903–1908), *Nebraska*[2]

Plants per hill	Yield per acre	Average weight of ear	Number of ears per 100 plants	Per cent barren plants	Yield of stover per acre
	bushels	*ounces*			*pounds*
1	48.3	10.5	161	3.0	....
2	67.7	10.6	115	4.8	5984
3	75.5	9.4	95	6.9	5972
4	76.7	8.2	82	8.3	6692
5	76.3	7.4	77	10.8	6969

Where corn is grown for grain there is no good reason for planting thicker than is necessary to secure maximum yield, but where grown for fodder or silage the rate may be increased one-fourth to secure the larger yield of stover.

Relation of Soil and Climate.—The best rate will vary with soils and climate. At the Illinois Station,[3] in a series of experiments covering the State, it was found that three kernels gave the best results on land producing more than 50 bushels per acre, and two kernels per hill where the land naturally produced less than 50 bushels per acre.

At the Indiana Station[4] corn was planted in drill rows from

[2] Nebraska Agricultural Experiment Station Bulletin 112, p. 30, 1909.
[3] Illinois Agricultural Experiment Station Bulletin 126, pp. 366–377, 1908.
[4] Indiana Agricultural Experiment Station Bulletin 64, p. 4.

11 to 19½ inches apart for a series of years. In seasonable years the best yields were secured with the thickest planting, and in dry years with the thinnest planting.

Effect of Season on Yield and Percentage of Grain

Stalks, inches apart	Seasonable, 1888–1891			Dry, 1893–1894		
	Bushels corn	Pounds stalks	Ears percentage	Bushels corn	Pounds stalks	Ears percentage
19½	49.76	3,617	49.1	22.07	3,092	33.3
16	54.05	4,065	48.2	21.27	3,143	32.2
14	57.79	4,158	49.3	19.39	3,762	26.5
15	57.81	4,201	49.6	14.28	5,204	16.1
11	59.14	4,960	45.5	13.80	4,360	18.1

QUESTIONS

1. How important is preparation of land?
2. Why does deep or shallow plowing not show consistent results?
3. Explain different systems for preparing corn land.
4. What are the reasons for believing deep plowing to be good practice?
5. Compare early *vs.* late spring plowing.
6. Can land ever be pulverized too fine?
7. When is hand planting practical?
8. Where is drilling general and good practice? Where check-row planting?
9. Does the method of drill or hill planting affect yield?
10. When does corn planting begin in the South? North?
11. How deep should corn be planted?
12. Explain the principles involved in rate of planting as affected by size of plant; fertility of soil; good and poor seasons.

CHAPTER X.

TILLAGE FOR CORN

Tillage Machinery.—Up to within comparatively recent times agriculture was practically without tools for intertillage. In fact, most of the crops, as wheat, oats, and barley, did not require intertillage. The hoe was the only special tool for this purpose, although the primitive wooden plow was also driven between the rows. The one-horse mould-board plow was quite generally used up to 1850 for corn and potato cultivation, and is still used in some parts of the South.

The great intertilled crops are corn, potatoes and cotton. Since 1850 there has been a rapid increase in the number and kinds of intertillage tools. The first tools were the "single shovel" and "double shovel" one-horse cultivators. The principal course of evolution has been to first attach two double shovel gangs to a sulky, so that a row could be cultivated at one time, then four gangs, so that two rows could be cultivated. The principal change in shovels has been to reduce the width and increase the number up to three to five shovels in the place of two.

Disk gangs are also used in place of shovels, and do excellent work on level loam soils.

Broad shears or blades which shave off a shallow surface are also successful where the ground is free from trash or stones, and the principal object is weed killing.

Weeders.—A class of tools with very narrow, flexible teeth, called weeders, are very useful in killing small weeds when the soil is in good tilth, but are not effective on compact soil. The weeder is extensively used in cultivating young corn the first three weeks after up, as it will destroy weeds in the hill without injury to the corn plants.

Lister Cultivators.—There have been devised for listed corn a number of special tools. The first of these tools was essentially a pair of wooden runners, set close together to follow the furrow left by the lister, with knives or shovels to work the ridge on either side

(Fig. 28). Later, metal wheels or disks were substituted as followers. These tools are used until the ridge has been partly worked down, then the ordinary shovel cultivator.

Reasons for Intertillage.—Intertillage is so universal for certain crops that we scarcely stop to ask the reason, assuming it necessary for growth.

The reasons differ somewhat, but the important reasons seem to be (1) to conserve moisture and (2) to destroy weeds. In addition, cultivation probably helps in many cases in freeing some plant food; also a well cultivated surface will probably take up more water, in

FIG. 28.—Two-row cultivator for listed corn at work.

the case of sudden heavy rainfall, than an uncultivated surface. The first two reasons, namely, conservation of moisture and destruction of weeds, are the points to give most attention.

Loss of Soil Moisture.—As fast as moisture evaporates from the surface, more water moves up from below. This is called the capillary rise of water, since its upward movement against gravity in the very small spaces between soil particles is similar to the rise of a liquid in a capillary tube. When these small "capillary" spaces are broken up, as by cultivation, the upward movement can not reach the surface, and water loss by evaporation decreases. Hence in a bare soil, without cultivation, water loss is large, and it has been demon-

strated on such soils (when undisturbed) that 30 to 60 per cent of the water lost may be saved by cultivation.[1]

Water Loss in Fields.—In a corn field conditions are quite different from those on a fallow soil. (1) Conditions favoring evaporation from the soil surface are largely removed. (2) The upward movement of soil moisture is intercepted by roots.

1. Set a pan of water on bare ground and another on the ground in a wheat field. The water surface in the open will lose moisture at the rate of one-half inch per day in dry weather, while the water surface in the wheat field will probably not lose as much in a week. A similar pan of water in a corn field will lose more than in a wheat field, being more exposed, but much less than on a bare (fallow) field.[2]

2. In a wheat or corn field a mass of roots fills the upper eight to twelve inches of soil, intercepting any upward movement of water. This would be especially true in a dry time, and it is doubtful if any appreciable amount of water could pass through this mass of roots to the surface.

Conserving Moisture in a Corn Field.—From the above we may conclude that in a fallow field moisture can be conserved by cultivation. That in a corn field, up to the time the plants are twelve inches high, the conditions are similar to a fallow field, but from this time on conditions rapidly change as the tops protect the surface and the roots occupy the soil.

Cultivation should be effective in conserving moisture during early growth, but not very effective after corn is five or six feet in height. This conclusion has been verified by numerous experiments, which the following will illustrate:

Effects of Different Treatments After Corn Is High

Place and duration of experiment	Weeds only scraped off with hoe	Average of cultivation treatments
	bu. per acre	*bu. per acre*
Illinois Experiment Station:		
Average for 5 years (Bulletin 31, 1894)......	68.3	68.6
Utah Experiment Station:		
Average for 8 years (Bulletin 66, 1900).....	58.8	55.8

[1] Widstoe, John A.: Dry Farming, p. 155.

[2] Nebraska Agricultural Experiment Station, Annual Report, 1911, p. 97.

Experiments by Cates[3] and Cox, recently reported, verify in general the above conclusions.

Effect of Weeds.—Weeds not only take up moisture but available plant-food as well. As the available plant-food in a soil is much below the needs of the crop, all taken by weeds directly robs the crop. Where weeds are allowed to grow the yield is almost nothing, while simply scraping the weeds off, as indicated in above experiments, results in yields comparable with thorough cultivation. The following results for one year show effect of weeds:

Reduced Yields Due to Weeds

Place of experiment	Weeds allowed to grow	Weeds scraped off	Shallow cultivation
New Hampshire Station (Bulletin 71, 1900)	17	...	80.0
Illinois Station (Bulletin 31, 1894)	none	28.7	36.1

The function of interculture for corn then appears to be (1) to conserve moisture and destroy weeds up to the time the plants protect the land, and after that (2) principally to destroy weeds. Broad, flat shovels or shears that merely shave the surface are very effective for killing weeds.

The above principles apply to all cultivated crops. The more nearly the field approaches a fallow field the more effective is cultivation for conserving moisture, while, on the other hand, the more the condition approaches that prevailing in a wheat field, the less need there is for conservation of moisture. For example, an onion field is not only exposed but onion roots are very short, and cultivation among onions is very important in conserving moisture. The same is true of many vegetable crops.

Depth of Cultivation.—There is no real necessity of cultivating deep if the work can be done while the weeds are small. Deep cultivation with wide shovels will often be necessary to cover up and destroy large weeds.

The depth of cultivation should be regulated so as not to destroy corn roots (Fig. 29). In heavy soils and wet seasons roots are often very shallow, from one to two inches below the surface; in dry seasons with loose porous soils, the upper roots will be three to four inches

[3] U. S. Bureau Plant Industry, Bulletin 257.

below the surface. These represent the extremes in depth of surface roots, and cultivation should be regulated accordingly. Cultivation deep enough to destroy roots has always decreased yield when compared with more shallow tillage.

Frequency of Cultivation.—Frequency of cultivation depends largely on the weeds to be killed. Rarely have experiments shown a

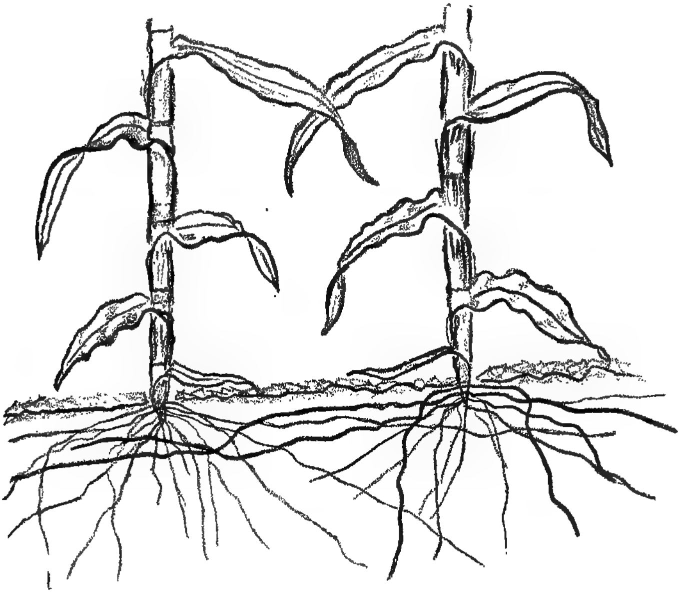

FIG. 29.—Drawing showing the distribution of corn roots in the soil.

profit for more than four cultivations, or for continued cultivation after corn was in ear, if free from weeds. At the Illinois Station, "ordinary" cultivation (about four times) was compared with frequent cultivation. Plats were also cultivated the same number of times, both deep and shallow.[4] Results were as follows:

Results of Different Methods of Cultivation

Kind of cultivation	Average yield for five years Bushels per acre
Frequent (4 plats)	68.6
Ordinary (4 plats)	68.5
Shallow (4 plats)	71.5
Deep (4 plats)	65.6

[4] Illinois Agricultural Experiment Station Bulletin 31, 356.

In a former book the author made the following summarized statement on the object of intertillage for corn [5]: "We may therefore conclude from the data presented that up to the time when corn shades the ground, and the field is comparatively fallow, cultivation conserves some moisture as in any fallow soil. After the corn crop is thoroughly established and a layer of surface roots intercepts capillary moisture from below, the principal service of cultivation is to destroy weeds."

QUESTIONS

1. Describe the evolution of tillage tools.
2. Give the two most important reasons for tillage.
3. Compare the loss of water by evaporation from a bare field and a field in crop.
4. What appears to be the most important reason for cultivation in a corn field?
5. Name cultivated crops where cultivation would probably be more necessary than in corn.
6. How should depth of cultivation be regulated?
7. How frequently may corn be cultivated with profit?

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[5] Corn Crops, p. 212.

CHAPTER XI

HARVESTING AND UTILIZING CORN

Methods of Harvesting.—The following practices are general in harvesting a part or all of the corn crop.

1. The whole plant harvested for fodder or silage.
2. Ears only harvested, the stalks left in the field.
3. Topping: the tops cut off above the ear while green, so the ear may ripen on the stalk.
4. Stripping: Leaves stripped off while green.

In the early history of corn culture in New England, it was the general custom to harvest the entire plant for fodder, and, when well cured, husk out the ears.

In the southern States the custom early became general of stripping off only the lower leaves and "topping" the upper part; that is, cutting off the plant above the ear. The ear was then allowed to remain on the stalk until mature, then "snapped" off and stored in the husk to protect from insects. The ears were husked as used.

The above customs are at present the common practices in both New England and the South. The acreage is generally small and the entire crop is saved.

With the settlement of the present "Corn Belt" States corn culture was extensive from the first. There was no need for coarse forage, so only the ears were harvested. In the Corn Belt only a very small percentage of the stalks is harvested. However, the custom of harvesting a part of the stalks is increasing, especially in dairy regions where corn is used for silage. The shortage of hay has also brought about an increase in the use of corn stover as a substitute.

Pasturing Corn Stalks.—It is the custom in the Corn Belt, also in the South, to turn in cattle, horses, or sheep, during the winter months, on the stalk fields after the grain has been harvested. There is no good data as to the relative amount of forage furnished by an acre of corn stalks, when cut and cured or when pastured after the grain has been harvested.

In a general way, the feeding value of the stalk fields approximates from one-third to one-half the value of the cured fodder.

Cost of Saving Stover.—According to experiments by the Minnesota Station [1] it costs $3.64 an acre more to harvest and shred the stover than to harvest only the ears. Zintheo [2] estimated from data collected that it cost from $1.18 to $1.50 per acre to harvest the fodder, and about 1.6 cents per bushel more to husk the grain from fodder than standing stalks, or a total cost of $2.00 per acre to secure

Fig. 30.—Harvesting corn by hand.

the fodder. With a yield of 1½ tons of stover per acre, stover would cost from $1.50 to $2.50 per ton for labor, according to the above figures.

Whether it will pay to harvest corn stover at the above prices will depend on the cost of producing other forage, as timothy, clover, or sorghums. In general a ton of good stover is estimated to be

[1] Wilson and Warburton: Field Crops, p. 85.
[2] U. S. Department of Agriculture, Office of Experiment Station, 173, 46.

worth a little less than one-half a ton of clover or alfalfa and about three-fourths of a ton of timothy. It would not be desirable to replace all the hay ration with corn stover, but when hay is worth $10 or more a ton a part of the hay ration can profitably be substituted by corn fodder.

Harvesting Corn Fodder.—Corn fodder is commonly harvested by hand (Fig. 30), where the acreage is small or the land is rough. With ten acres or less to cut it would not pay to own a binder, as the depreciation and interest on the binder (which costs about $125) would increase the cost too much. However, one can

FIG. 31.—Harvesting corn with a corn binder.

often hire a binder to do the cutting, at about the same cost as by hand, with the additional advantage of having the fodder bound.

Sled harvesters, costing from $5 to $15, are cheap and satisfactory. These machines cut one or two rows at a time and are very satisfactory where the corn is to be shocked and husked in the field. Also the harvesters built on the same principle, but mounted on wheels, are in common use.

Corn Harvesters and Binders.—The attachment of a binding apparatus to a corn harvester was first successfully applied about 1895. Since then the corn binder, as it is called, has generally replaced other methods (Fig. 31). This is especially true where the

fodder is to be put in silos, as it facilitates handling, a rather laborious task with green loose fodder.

Shocking Fodder.—Where the fodder is cut by hand with knives it is usually set directly into shocks of about 10 to 14 hills square. This is about as large a shock as can be depended on to cure out properly. Later the ears may be husked and several shocks set together if the fodder is to remain in the field. The large shock protects the fodder better, especially if it is intended to leave it in the field for several months.

When cut by sled harvesters, or wheel harvesters built on the same principle, the green fodder may be immediately set into shocks, or left in piles on the ground until half dried, then set up into very large shocks and securely tied. The same plan may be followed with bound fodder.

Hauling and Storing Fodder.—Corn fodder is commonly hauled in on a rather damp day, as leaves are easily broken off when very dry. The fodder may be stacked, but care must be observed that it is well cured and that the stacks are narrow, as it is very apt to develop spontaneous heat to a high temperature. For the same reason care must be exercised when storing in barns. Frequently the fodder is hauled and set up in a yard, only one tier in depth.

When to Harvest Fodder.—It has been clearly shown by many tests that the yield of dry matter increases up to maturity. This is illustrated by the following table, which is taken from results secured by the Michigan Station [3]:

Yield per Acre of Green Corn Fodder and Dry Matter

Time of cutting	Green fodder	Dry matter	Per cent dry matter	Per cent water
	pounds	*pound*		
August 10 (tasseled)	21,203	3,670	17.3	82.7
August 25 (in milk)	25,493	5,320	.209	79.1
September 6 (glazing)	25,865	7,110	.725	72.5
September 15 (ripe)	23,007	8,020	34.8	65.2

While the corn plant was full height August 10, when tasseled out, yet it had developed at that time less than one-half its dry matter. Also note the high water content at the early stages.

[3] U. S. Department of Agriculture, Farmers' Bulletin 97, 12.

It has also been shown that the dry matter improves in quality as the corn matures. There is an increasing proportion of starch and sugar.

Relative Proportion of Parts.—In good corn, that will make 50 bushels per acre, about one-half the dry weight is represented by the ears and one-half by the stalk and leaves. This does not represent the relative feeding value, as the ear is more valuable pound for pound than the other portions. Feeding experiments show from 60 to 70 per cent of the digestible nutrients in the ears.

With low yields the proportion of ear is much less. For example, at the Indiana Station [4] records were kept in one series of experiments for a number of years, on the yield of ears and stover. Some years were favorable and the yield was good and other years were adverse. Results were as follows:

Proportion of Grain Loss With Light Yields

Seasonable years, 1888–1891			Dry years, 1893–1894		
Yield per acre		Percentage of ears	Yield per acre		Percentage of ears
Grain, bushels	Stalks, pounds		Grain, bushels	Stalks, pounds	
55.7	4200	48.3	18.6	3912	25.2

Therefore fodder or silage from a large crop of corn is more valuable ton for ton than from low-yielding corn.

Husking Ears.—Ears are commonly husked by hand from the fodder or standing corn. To aid in this a "husking peg" or hook is used on the hand. When fodder is shredded the husking is commonly done by the machine. There is also a machine for husking from the standing stalks, but this is not in general use as it is only very little cheaper than hand husking.

Storing Ears.—In the central and northern States the ears are commonly stored in ventilated cribs, until thoroughly dried. The corn may then be shelled out and stored in bins. It is not safe to store shelled corn in bins or even ear corn in cribs, if the corn has 18

[4] Indiana Agricultural Experiment Station Bulletin 64, 4.

per cent moisture. When dry (13 per cent moisture) many thousand bushels may be safely stored in a tight bin.

Shrinkage of Corn in Curing.—There are two causes of shrinkage in stored corn, (1) loss of water, (2) loss of dry matter. During the first 12 months after harvest ear corn will lose from 5 to 20 per cent in weight, depending principally on how dry when husked. Air-dry corn one year old will have from 10 to 14 per cent moisture, depending on the climate. After that the degree of moisture will vary with the degree of moisture in the air. It has been noted that corn shipped from a very dry climate to a more humid one, would actually gain in weight in transit.

There is also another loss due to the very slow decomposition or oxidation of dry matter, amounting to 1 to 3 per cent in a year.

In silos this loss of dry matter is very high, amounting in some cases to as much as 20 per cent. In fodder corn, in addition to some oxidation that may take place, there is always considerable loss of leaves in handling. Ordinarily, the loss in fodder corn before it is fed amounts to 10 to 20 per cent.

Cost of Producing Corn.—When the Prairie States were first broken up, corn was produced very cheaply in the corn belt. The yields were large with a minimum of labor. Data taken in the corn belt from 1885–1895 show an acre cost of $6 to $8 and a bushel cost of about 20 cents. From 1895 to 1905 various records show the acre cost to be $10 to $14, and bushel cost from 24 to 30 cents. In the eastern States the cost has always been much higher than this, ranging from 40 to 50 cents per bushel.

Data collected by the U. S. Department of Agriculture for the year 1909, show an average cost for the United States of 37.9 cents per bushel, while for Illinois and Iowa, the two leading corn States, the bushel cost was 31 and 30 cents, respectively.

How Silage is Made.—Vegetable matter is caused to decay through the presence of bacteria or molds. Two methods are used to preserve materials, (1) by drying, as moisture is necessary for growth of bacteria or molds, (2) by heating to destroy, and some preservative to keep out the organisms.

The preservation of silage is by the latter method. The green forage is usually cut into short lengths, of one inch or less, so it will

pack closely. Natural heat soon develops, which destroys organisms. At the same time the air is used up and carbon dioxide gas, given off by the decomposing silage, takes its place. The carbon dioxide is a preservative, and no further decomposition can take place. However, the carbon dioxide gas is heavier than air, so the silo must be tight or the gas will leak out and air coming in will cause further decomposition. Any kind of green material can be preserved in a silo. Even part dry material can be so preserved, if it is well wet down and closely packed. Corn fodder which has been cut a week or more, or frosted, is sometimes kept in a silo by wetting down.

USES OF CORN

The principal reason corn has such extensive cultivation is due to its great value as stock feed, and the fact that it yields more grain per acre than any other cereal. The great development of the fat stock industry in the Middle West is due largely to the supply of corn for feed.

Perhaps nine-tenths of the corn crop is fed directly to stock. The other one-tenth is manufactured into a great variety of products, but mostly food products. The three most important uses of corn in the arts is the manufacture of glucose, cereal foods, and alcohol.

Glucose is made by first degerminating the corn, then treating the starchy portion with dilute hydrochloric acid, which converts the starch to glucose.

Cereal foods are of two classes, as the (1) corn meal and hominy products and the (2) cooked and flaked "breakfast" foods. Corn meal is made in two ways. The whole corn may be ground and only the coarse parts, consisting largely of bran, sifted out. This meal contains considerable germ. The germ meal present gives its own flavor, which is rather agreeable but makes the meal more difficult to keep. Degerminated meal is made by cracking and removing the germ. The cracked product, after germ and hull are removed, is called *hominy*. This coarse hominy may be sold in this way, or ground further into meal. This is commonly called "fancy" meal, and is the kind most commonly on the market.

Flaked cereal foods are made by cooking the hominy, then rolling out into thin flakes, and further cooking in a dry oven.

Starch is made by first removing germs, grinding fine, and then washing the starch out by water.

The **germs,** removed in the manufacture of glucose, meal, or starch, are usually pressed until all the oil is extracted. This oil is used as a salad oil, in paints, or is vulcanized as a substitute for rubber. The residue after oil is extracted is corn oil cake and makes a valuable stock feed, being very high in protein.

Distillery products are the residue as a result of distilling alcoholic beverages. These products are practically all used as stock feeds.

Pop-corn is either eaten fresh as popped or manufactured into a variety of confectionery products.

Sweet corn is commonly eaten green, from the cob, or cut from the cob and canned. Canning corn is an important commercial industry.

Importance as Food.—In Colonial days corn was an important article of food, and generally used. However, with the development of wheat culture, corn has been almost entirely superseded in all but the southern States. In the South, corn bread is still used extensively.

QUESTIONS

1. Explain the customary methods of harvesting corn.
2. Where are the stalks generally harvested and where not harvested?
3. Under what conditions is it profitable to harvest corn stalks?
4. Describe what you regard as a good method of curing and keeping corn fodder.
5. How would you determine best time to harvest fodder?
6. Explain change in water content.
7. What proportion by weight in the ears?
8. What proportion of feeding value?
9. How dry should corn be for storage?
10. What shrinkage is expected in storage of ears? Storage of silage?
11. Figure out what it costs to produce corn in your community.
12. Explain the principles of silage making.
13. How is the corn crop utilized?
14. Name some of the important manufactured products.

CHAPTER XII

CORN INSECTS AND DISEASES

Corn is practically free from the attacks of insects and diseases. There is no disease that does great damage, though occasionally corn smut may do considerable damage. Insects are also easily controlled with the exception of the corn weevils in southern States.

Corn Insects Below Ground.—Insects attacking corn may be grouped in two classes, as (1) those working below ground and (2) those above ground. The corn *rootworm* and *root-louse* are most important of those below ground. Both of these can be easily controlled by rotation. Both live over in the soil, and usually do not become very destructive until the land has been in corn three years in succession. A change to any other kind of crop for one to two years is effective in destroying them.

Two other insects, the *wireworm* and the *grubworm,* are not peculiar to corn, and therefore are not controlled so easily by rotation. In fact, both are apt to be more destructive after sod than at any other time. The wireworm does most damage by boring into young plants, soon after they come up. The grubworm lives under the corn plant most of the summer, eating off the roots. The only remedy suggested is to fall plow the land, late in the season, to expose the larvæ and worms to winter killing.

Cutworms do some damage to young corn, and occasionally may completely destroy a stand. Usually the cutworms pupate in June, so a second planting made, running the rows half way between the first rows, will usually escape with little damage.

Insects Above Ground.—*Earworms* and *bill bugs* ordinarily do only slight damage. Occasionally the earworm may damage to considerable degree the market value of sweet corn to be sold green on the ear.

Migratory insects that occasionally damage corn are *chinch bugs, army worms,* and *grasshoppers.* Chinch bugs and army worms, moving on the ground, can be prevented from entering a

cornfield by plowing a ditch, and maintaining a dust barrier in the ditch by dragging a log or harrow to and fro.

Birds and Rodents.—*Crows* pull up green corn to secure the grain as food. They do damage principally in regions where the corn area is comparatively small. Scarecrows of various kinds will keep them away, if placed close enough together. Coal tar on the seed is a deterrent, though not a sure preventive. The tar is applied by dipping a wooden paddle in the hot tar and stirring in the seed corn until each grain is coated. It may be necessary to add a little meal, sand, or sawdust to keep the corn from sticking.

QUESTIONS

1. Name the important corn insect enemies working below ground.
2. Can you suggest methods of control?
3. What important insects work above ground?
4. Can you suggest methods of controlling crows and rodents?

CHAPTER XIII

POP-CORN AND SWEET CORN

THE general information given in regard to the culture of field corn applies to the production of pop- and sweet corn. The culture differs in only a few particulars.

POP-CORN

Pop-corn is raised wherever field corn is grown, but as a commercial crop it is produced principally in Iowa and Nebraska. The plants being small, it is planted about twice as thick as field corn. It is slower in growth and more delicate, requiring greater care and skill in cultivating.

Varieties.—There are two distinct types of pop-corn. One is known as rice pop-corn and is distinguished by a sharp pointed tip on the kernel. The other is the pearl pop-corn, the kernels being round and smooth. Market demand is mostly for the rice variety of white color, and this is grown almost exclusively for commerce. In color, there are red, yellow, and blue varieties of both rice and pearl pop-corn.

In size, the ordinary ear of white rice is four to five inches in length, but certain strains are larger; while some varieties of pearl pop-corn attain a length of eight inches. Tom Thumb is a dwarf variety of pearl pop-corn with stalks not much more than thirty inches in height, and ears about two inches long. This is the smallest variety of corn known. Care must be taken to grow only varieties that mature well before frost.

Harvesting.—Pop-corn is usually allowed to ripen and dry out well on the stalk, before harvesting. It is then stored in well-ventilated cribs until air dry, when it is shelled and sacked for market. A good yield is 2000 pounds of shelled corn per acre.

Marketing.—In centers where pop-corn is grown extensively, as Sac County, Iowa, and Loup County, Nebraska, special elevators and storage houses for handling the crop have been built. It is usually sold in car lots, either to wholesale merchants or to confectionery manufacturers.

SWEET CORN

Sweet corn is grown in the vicinity of large cities as a truck crop, to be sold green on the ear. It is also grown very extensively in some places as a canning crop. New York, Illinois, Maryland, Pennsylvania, and Ohio are the principal States in acreage of sweet corn.

Varieties.—For canning and general crop, large late varieties are generally used, requiring 100 to 110 days to produce roasting ears. However, the market gardener requires early corn for at least a part of the crop, and great effort has been made to develop early varieties. There are many varieties that will produce good ears in 60 days from time of planting.

Harvesting.—Green corn is always harvested by snapping the ear, and selling in the husk. It takes care to tell by feeling whether the ear is just right to harvest, without tearing back the husk. Much corn is marketed too green.

For canning, the corn is hauled to the factory in the husk and sold by the ton. Yield varies from three to five tons per acre, and price from $6 to $9 per ton. Four tons at $8 is considered satisfactory.

At the factory the corn is both husked and cut from the cob by machinery.

EXERCISES

Study of Corn Types.—*Materials.*—Ears representing the five principal types of corn; also grains of each that have been prepared by soaking for 24 hours.

Make drawings of grains of each of the above types, showing the relative proportion of (1) hard starch; (2) soft starch; and (3) germ.

I. Use the following system in sketching the parts:

Hard starch=Parallel lines.
Soft starch=Blank.
Germ=Solid penciling.

First Drawing.—A view of the germ side of the kernel, after shaving with a sharp knife, exposing the germ.

II. Make a thin longitudinal section of a dent corn germ, by splitting the kernel cross-wise of the dent. Examine under a microscope or magnifying lens.

Make a drawing showing the vegetative portion of the germ imbedded in the scutellum, labeling all parts carefully.

Divisions of the embryo are:

Scutellum, enclosing vegetative parts.

Vegetative parts: Plumule, or plant tip; node, point of attachment; radicle, or root tip.

III. Draw a kernel in the first stages of growth.

IV. Draw a kernel in advanced stage of germination, showing temporary roots, plumule, radicle, and root-hairs.

V. From your readings in the text, prepare answers to the following questions:

1. What is the function of the endosperm, scutellum, plumule, radicle, root-hairs?

2. Where do the temporary roots develop? Where the permanent roots?

QUESTIONS

1. Compare field corn and pop-corn culture.
2. Describe the two principal types of pop-corn.
3. Where is pop-corn grown extensively?
4. Name the regions where sweet corn is grown.
5. What is a fair yield of sweet corn?

CHAPTER XIV

CORN JUDGING

CORN judging is the art of selecting an ear or exhibit of ears, according to a standard of perfection. With well-established breeds of live stock, recognized types are accepted for each breed. In judging corn, the attempt was made to establish a standard for each variety to be judged. This plan has not succeeded with corn so well as with live stock, due to the influence of soil and climate on the type. In fact, it was soon recognized that some change in type was desirable if the variety was to have a wide adaptation. However, certain type characters should be permanent, such as color, and within reasonable limits other characters, such as shape of grain or indentation, should be fairly constant.

While judges do not pay strict attention to variety standards, yet certain characters have come to be recognized as essential in all good samples of corn.

These characters may be classed in two groups, as those pertaining to soundness and maturity, and those pertaining to fancy points. Maturity and soundness have to do with the selection of all seed corn, but the fancy points do not necessarily have to do with seed selection.

PRACTICAL CHARACTERS

Maturity.—It is important that corn should fully mature before frost comes. Immature corn does not keep well, and quickly loses its germinating qualities. The immature ears are usually loose, so the ear may be twisted. The kernels are also likely to be shrunken, especially toward the tip.

Soundness.—This quality has to do with any injury that may have occurred to the corn, through the action of fungus diseases, decomposition, or loss of germination. Loss of germination is most important, as it has such an important bearing on yield. The inspection of corn for germination has been discussed heretofore (p. 63).

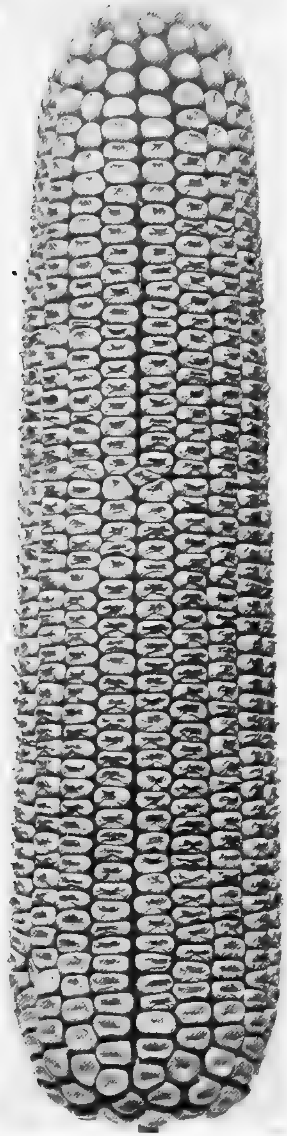

FIG. 32.—An ideal ear of dent corn of fancy type.

FANCY CHARACTERS

Under fancy characters are included all those considerations that have to do with the symmetry and uniformity of the ears. This includes shape of ears and kernels, straightness of rows, and filling over butt and tip (Fig. 32). These points have some practical value, as they indicate the care and skill with which the corn has been selected and grown, but do not *always* have a direct bearing on ability to yield, and hence are of secondary importance. In general, the standards which have been adopted for dent corn are described as follows:

Shape of Ear.—The shape should be, in general, cylindrical, with a circumference about three-fourths of the length. There are less irregularities in a cylindrical ear than in a tapering. An ear is tapering from two causes, (1) extra rows in the butt end, or (2) the kernels become shorter toward the tip.

Butts of Ear.—Regular, with as few misshapen kernels as possible. The butt should not be enlarged or tapering, but almost the same circumference as the middle. A large, coarse shank increases the difficulty of husking. If the shank is too small the ear is apt to drop off.

Tips of Ears.—The full length of kernel without much change in size should be carried up to near the tip. The rows should be regular and carried well over the tip, so not more than a small tip of cob is exposed.

Shape of Kernels.—In dent corns, the proportion of length to width varies. In some early varieties the kernel is as broad as long, while in most of the very large, late dents the kernel is only one-half as broad as long. Some allowance must be made for variety, but, in

FIG. 33.—Shape of ear. On left a cylindrical ear; center, tapering ear; right, tapering butt.

general, the kernels should be much longer than broad, and so shaped that they fit very neatly, at tip and crown, with no wide spaces between. Space between the kernels at the cob usually indicates poor growth or immaturity.

Character of Germ.—Generally a large germ will give a more vigorous plantlet than a smaller germ. The germ should be of both good color and texture. Any discoloration is likely to mean poor germination. The texture and color are determined by cutting with a knife.

Color.—In some cases, there is a recognized shade of white or yellow, which should be considered. In all cases, the kernel should be bright and with a good luster when shelled. Mixed or off-colored grains indicate hybrids and are, therefore, undesirable in fancy corn, though they may not injure yield. A uniform bright color of cob is also desired.

The Score Card.—To facilitate judging, score cards have been prepared. Score cards differ in the number of points considered and the relative value assigned, depending somewhat on local conditions. Expert judges seldom use the score card except for very close comparison, as they learn by practice to value the ears readily at a glance.

Terms for Describing Corn.—In describing plants or animals it is first necessary to come to a common understanding as to the exact meaning of technical terms. For example, in describing corn the terms "rounded kernels" or "keystone kernels" should convey an exact meaning.

Following are the descriptive terms generally used:

A. Ear
- Shape (Fig. 33):
  - Cylindrical
  - Tapering
  - Conical
- Proportions:
  - Long, cir.=½ length
  - Medium, cir.=¾ length.
  - Short, cir.=to length
- Tips (Fig. 34):
  - Covered
  - Exposed
- Butts (Fig. 35):
  - Enlarged
  - Symmetrical
  - Contracted

B. Rows
- Spacing:
  - Wide
  - Close
- Arrangement:
  - Paired
  - Single
- Number

C. Kernels
- Shape—broad view (Fig. 36):
  - Round
  - Square
  - Keystone
  - Pointed
  - Shoepeg
- Shape—edges:
  - Parallel
  - Pointed
- Crown:
  - Pointed
  - Smooth
  - Dimple
  - Deep dent
  - Pinch dent

Depth (Fig. 37):
Shallow, less than 6/16″
Medium, 6/16″ to 8/16″
Deep, more than 8/16″

Shank—size:
Large, equal to cob
Medium
Small, one-half size of cob

Practice Work.—Describe a few ears, all of one variety, then ears of the several species of corn, as pop-, flint, etc.

Outline for Describing Corn

Variety name................................Date..................

Number of ear					
Ear:					
Shape................	....	....	....	....	....
Proportions............	....	....	....	....	....
Tips................	....	....	....	....	....
Butt................	....	....	....	....	....
Rows:					
Spacing................	....	....	....	....	....
Arrangement............	....	....	....	....	....
Number................	....	....	....	....	....
Kernels:					
Shape, broad............	....	....	....	....	....
Shape, edge............	....	....	....	....	....
Crown................	....	....	....	....	....
Depth................	....	....	....	....	....
Shank:					
Size................	....	....	....	....	....

CORN JUDGING

Corn judging is largely based on certain artificial standards of perfection. Judging consists in determining how closely a certain ear or set of ears conforms to the ideal standard. The practice is useful in developing powers of observation and critical examination.

In order to insure that all characters of the exhibit are examined in a comparative way, each character is considered separately and a value given the character in accordance with its importance. The characters may be classed into two groups, namely, practical points and fancy points.

Practical points deal with those characters that have to do with the seed value, as germinating quality.

Fancy points deal with those characters that have to do with symmetry and trueness to type, as shape of ear or shape of kernel.

The score card is used by beginners to insure systematic work,

but after a while the score card may be discarded. Experienced judges seldom use a score card.

Many score cards have been devised. All cards are arbitrary. The greatest problem has been to determine just what points to use and what value to give each. The general tendency, however, has been to shift the weight from fancy characters to practical characters. The following score card is patterned on several now in use.

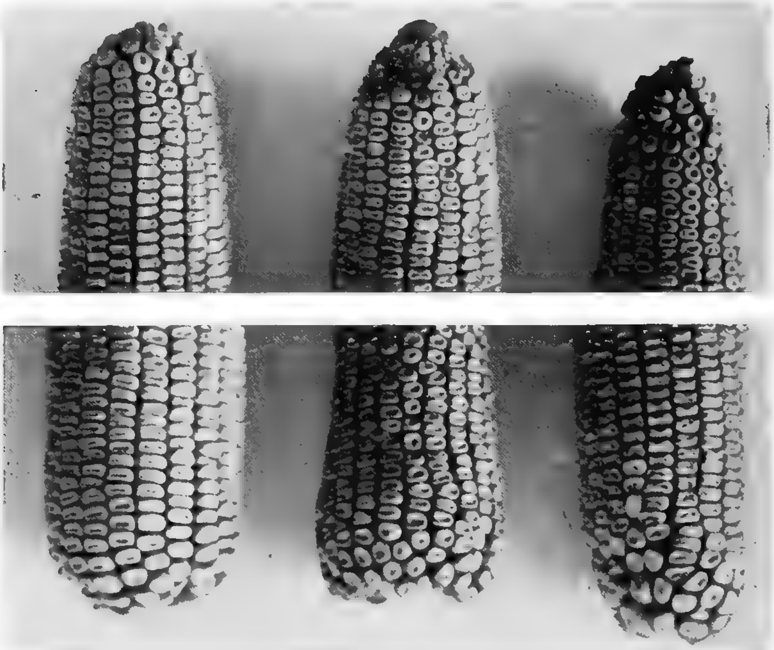

Fig. 34.—Tips of ears. Left to right, well-covered tip, exposed tip and very tapering tip.
Fig. 35.—Butts of ears. Left to right, well-shaped butt, expanded butt, and contracted butt.

Explanation of Points.—The following explanation of points will serve as a guide, but experience is required for safe judgment.

Cuts.—Where a 10-ear exhibit is judged and 10 points are given to a character, as "shape of ear," it means that one point is cut for each ear off shape. This, however, is the extreme cut and is modified according to judgment.

Fancy Points.—*Shape and Proportions.*—First examine an ideal ear of the variety to be judged. In general, the shape should

be cylindrical, except in certain varieties. The proportions of circumference to length for dent corn are about 7 or 8 to 10, for flint corn 6 to 10. There are a few extreme types, as cob-pipe corn, where the proportion is 10 to 10. For dent corns use 7 or 8 to 10 as the standard where not otherwise specified. *Cut one point for each off ear.*

Tips of Ears.—Three characters are considered in examining the tip: (1) straight, regular rows; (2) depth of kernel—the kernels should be approximately as deep near the tip as in the middle of the

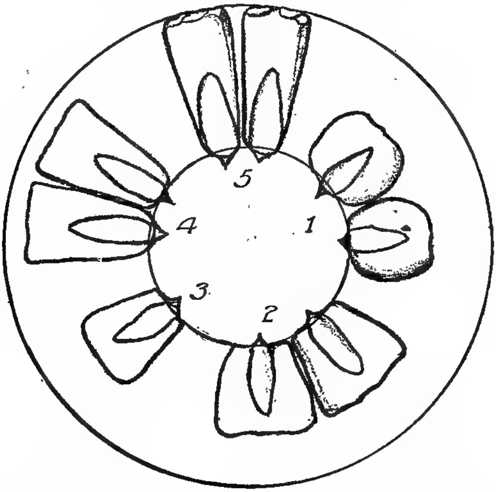

Fig. 36.—Shape of kernels. (1) round; (2) square; (3) short keystone; (4) deep keystone; 5 shoepeg.

ear; (3) exposure of cob. A slight exposure is not objected to if the tip is good in other points. Much exposed cob, however, is taken to indicate lack of adaptation. *Cut one-half point per ear.*

Butts of Ears.—The butt end should (1) have regular rows; (2) kernels should be full depth and shapely; (3) the shank scar should be medium in size; (4) the grains should be well rounded about the shank; (5) the butt should neither be expanded, due to enlarged cob, nor contracted, due to short grains or irregular rows. *Cut one-half point per ear.*

Spacing of Rows.—The spacing and shape of kernels can be examined at one time. For this purpose remove several kernels near

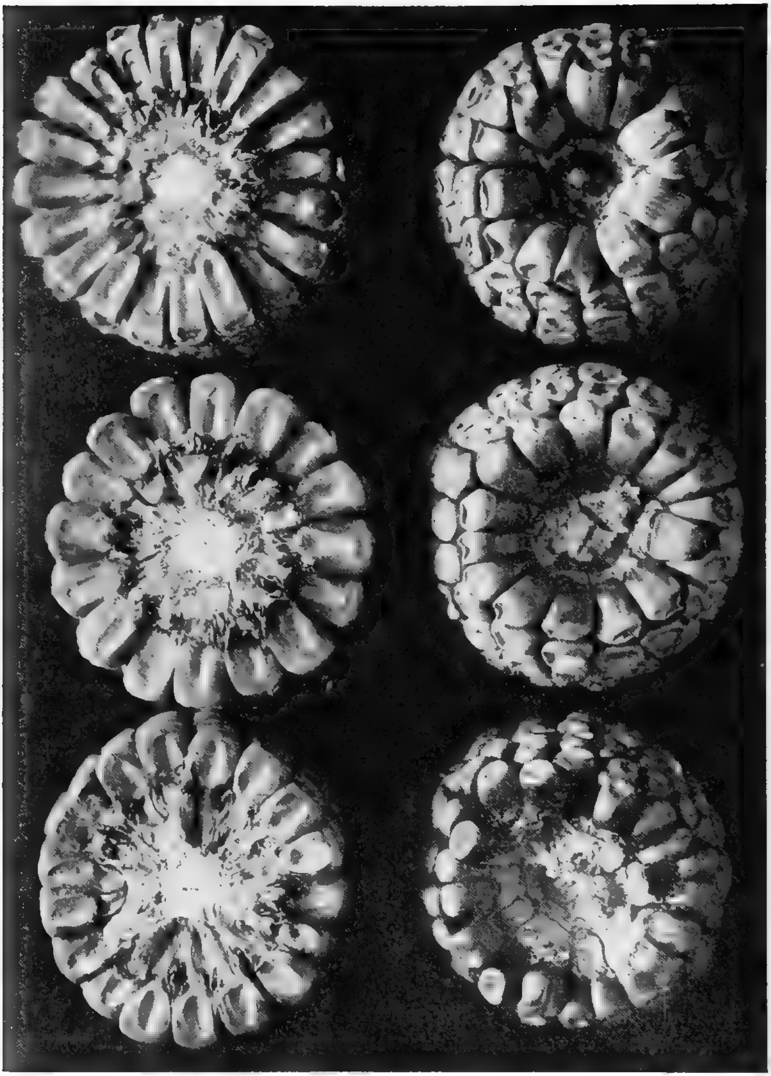

FIG. 37.—On left, shallow, medium and deep kernels. On right, large shank, medium, and too small (slightly reduced).

middle of ear. The kernels should be plump and of such shape that the crowns fit close together, and there should be no space at the tip. *Cut one-half point per ear.*

Shape of Kernels.—First examine a few ears having good shape of kernel. The kernel should not be too narrow or thin. The kernels should be of such shape as to fit neatly, with no lost spaces, and the tip especially should be plump. A keystone suggests the ideal shape. *Cut one point per ear.*

Uniformity in (1) size of ear; (2) shape of ear; (3) indentation; (4) kernel. Uniformity is a strong indication of trueness to type (Fig. 38). A good exhibit is assumed to be uniform. In judging uniformity the ears are best sorted according to type in each case. For example, ears having similar identation are placed

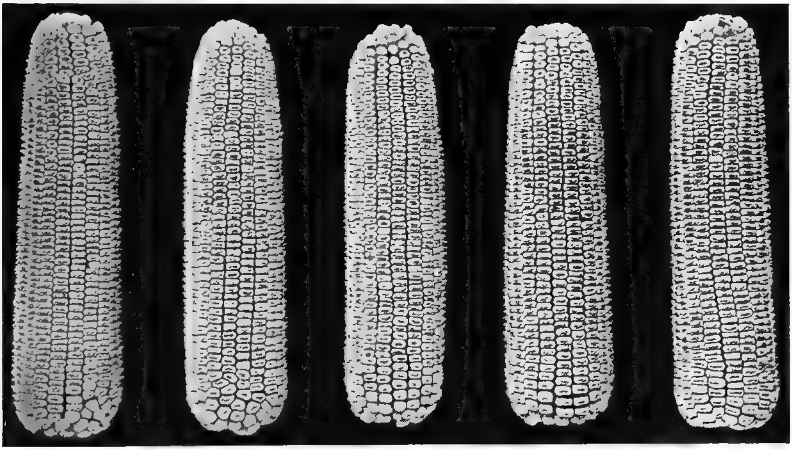

Fig. 38.—A well-selected exhibit of fancy ears. Note their uniformity in all characters.

together. In a certain case you may have six ears with one kind of indentation, three with another, and one of another. Give the exhibit credit for six, the largest number of a kind.

Proceed in the same way with the other characters. *Cut one-half point per ear.*

Practical Points.—*Maturity.*—A lack of maturity is indicated in several ways: (1) ear soft, so it can be twisted with the hands; (2) kernels discolored at the tips, due to poor drying; (3) kernels blistered, the hull being raised in places due to frost or freezing while green; (4) kernels badly pinched at top, indicating lack of full development. *Cut one point per ear.*

Plumpness of Grain.—A pointed grain at the tip is likely to indicate poor germination and lack of maturity. A pinched grain at top may indicate (1) lack of adaptation; (2) corn too large for soil, thus not being able to fully mature; (3) lack of maturity due to frost. *Cut one point per ear.*

Color or Luster.—Discoloration usually indicates injured germinating quality, or immaturity. Grain with a bright luster and no discolor always germinates well, and comes from sound, mature ears that have been well preserved. Discoloration on tip or back of kernel always means a wet cob or soggy ear and poor curing.

Off-colored grains, as white grains in yellow corn, mean mixture. Disqualify all ears showing signs of mixture. *Cut one point per ear.*

Quality of Germ.—First study the appearance of germs in ears that have been tested and are known to be of good germinating quality.

A good germ should have a cream white color, wax-like in texture, with only a small air-space about the plumule. Poor germs are most commonly indicated by (1) dark color in some part; (2) dry or shrunken. *Cut one point per ear.*

Score Card for Corn

Number of sample or ear		1	2	3	4	5
Fancy points indicating trueness to type (55)	*Points*					
1. Shape and proportions of ear	10					
2. Tips	5					
3. Butts	5					
4. Spacing of rows	5					
5. Shape of kernels	10					
6. Uniformity of ear (20)						
(*a*) Size	5					
(*b*) Shape	5					
(*c*) Indentation	5					
(*d*) Kernel	5					
Practical points indicating adaptation and viability (45)						
7. Maturity	10					
8. Plumpness of kernel	10					
9. Color of kernel	10					
10. Quality of germ	10					
11. Size of shank	5					
	100					

Size of Shank.—A large, heavy shank (1) makes corn difficult to husk; (2) likely to go with a large, wet cob that cures out slowly. A very small shank will break easily, allowing many ears to fall to the ground. The shank should be from one-half to three-quarters the size of the cob. *Cut one-half point per ear.*

Practice Work in Scoring Corn.—In learning to judge corn it is best to confine attention at first to single characters, until the ideal for each character has been firmly fixed in mind. The following method has been found very practical:

Placing Single Ears.—(1) With a ten-ear exhibit for practice, pick out the ear that is best in "shape and proportion." Next pick out the poorest, then arrange the 10 ears in order of merit when this point only is considered.

(2) Second, take the next point on the score card and arrange the ears according to tips, and so on through all the points.

(3) Pick the best ear when fancy points only are considered.

(4) Pick the best ear when practical points only are considered.

(5) Pick the best ear all points considered.

(6) Repeat with other 10-ear exhibits.

Scoring 10-ear Exhibits.—When a 10-ear exhibit is to be scored, it is the general custom to proceed by sorting the ears as each point is taken up. Draw toward you those ears that will pass without a cut; push from you a little the ears that are readily seen to need the full cut. This gives three classes and enables one to quickly form judgment as to a fair cut on the exhibit.

Disqualified Exhibits.—In practice it is the custom among judges to entirely disqualify an exhibit that shows more than one ear with dead germs or more than one ear showing mixture. An exhibitor is allowed to remove a few grains near the middle of each ear for examination, but the judge is privileged to bar corn showing too many grains missing.

QUESTIONS

1. Define corn judging.
2. Is it practical to have a fixed type for a corn variety?
3. Name the two groups of characters in corn judging.
4. Which do you think of greatest practical importance?
5. How would you determine maturity? Soundness?
6. What are fancy characters?
7. Do they have a bearing on ability to yield?
8. Define a good shape of ear; butt; tip; kernel; germ; and color.

CHAPTER XV

WHEAT

WHEAT is the most valuable of the important food plants of the world, though in actual tons of production it is exceeded by both potatoes and corn (see p. 3). Europe alone produces about one-half of the world's wheat, and North America about one-fourth.

The Production of Wheat.—The wheat crop of the world for the 5-year period, 1906–1910, is shown by the following table, as reported in the 1910 Yearbook, U. S. Department of Agriculture:

Continent	Bushels
Europe	1,800,705,600
North America	833,815,000
Asia	448,136,600
South America	178,293,800
Australasia	75,941,000
Africa	67,101,600
Total world crop	3,403,993,600

The principal wheat-producing countries (Fig. 39), together with the average yield per acre for two decades, are shown in the next table.

Yields Per Acre in the Leading Wheat-growing Countries

Country	Average yield per annum, 1906–1910, bushels	Average yield per acre 1890–1899, bushels	Average yield per acre 1900–1909, bushels
United States	693,316,000	13.2	14.1
Russia	557,757,000	8.9	9.7
France	328,848,000	18.6	20.5
India	301,452,000	...	12.0[1]
Austria-Hungary	225,148,000	16.6[2]	17.7
Italy	169,907,000	...	...
Argentina	154,117,000	...	...
Germany	138,184,000	24.5	28.9
Canada	129,926,000	...	18.2[3]

The United States and Russia are the leading wheat-producing countries. They also lead in oat production (Chapter XX). Germany is also a great oat-producing country, but much lower in total

[1] Estimated, no accurate data.
[2] Austria only.
[3] 1906–1910 only.

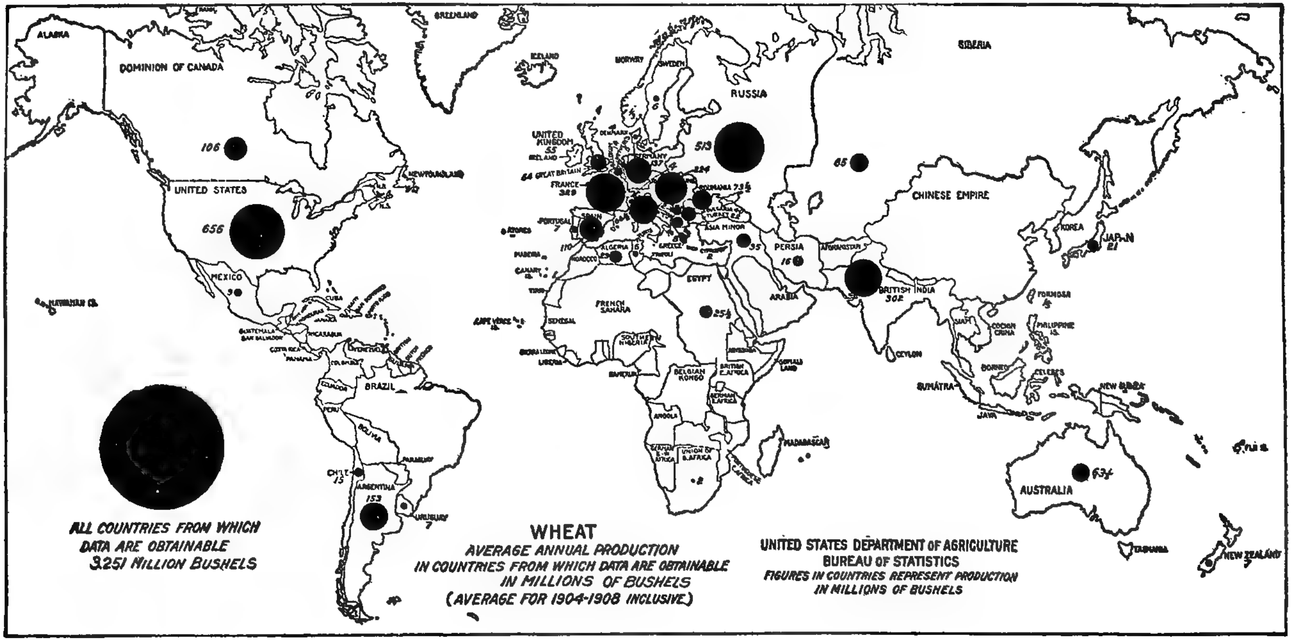

FIG. 39.—Production of wheat in the world.

wheat production, due to the fact that rye is so extensively used in that country for bread. Wheat is usually raised in great level plain regions, where the climate is rather dry, and the average yield per acre low. The yield is higher in the humid regions, but there other crops are often raised more profitably. It will also be noted that the average yield of wheat per acre is increasing, when the two last 10-year periods are compared.

Wheat in the United States.—The great wheat belt lies somewhat west of the oats region and corn region, though they all overlap

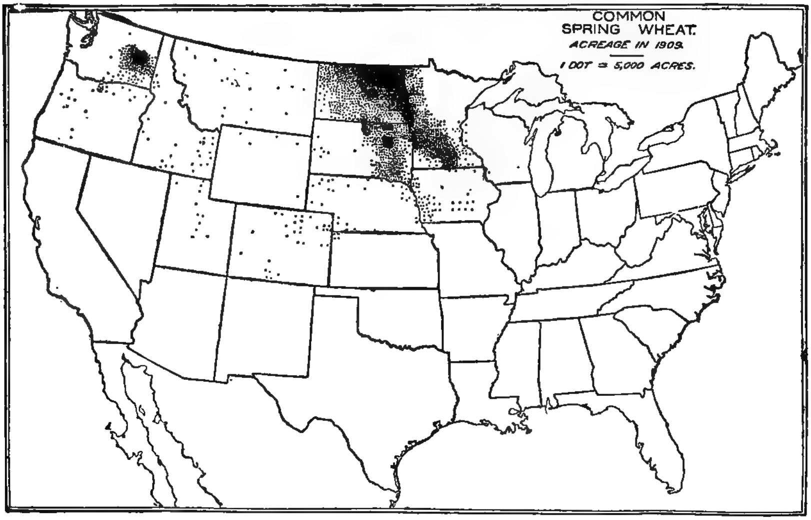

Fig. 40.—Spring wheat production. (U. S. Department of Agriculture.)

in the Missouri River Valley. The five leading wheat states in order of production are North Dakota, Minnesota, Kansas, South Dakota, and Nebraska. These five states produce almost one-half the wheat crop.

Production Not Increasing.—Wheat production is still increasing in all the above states except Minnesota, where it is now on the decline. Wheat production is also increasing in the Rocky Mountain States, but in all other sections of the United States production is declining. Up to the year 1899 the wheat acreage steadily increased, from 15,000,000 acres in 1866 to 52,000,000 acres in 1899, but has remained about stationary since then, the decline in older regions offsetting the increases in newer regions.

The following data show the total production in the United States and five leading states for the five years 1906–1910:

State	Total yield, bushels	Yield per acre, bushels
Kansas	73,273,000	13.4
North Dakota	70,868,000	10.6
Minnesota	68,626,000	13.9
Nebraska	45,936,000	18.4
South Dakota	41,215,000	12.8
Total	299,918,000	...
United States	693,316,000	14.68

The yield per acre is not high in the wheat belt, but the acreage is large.

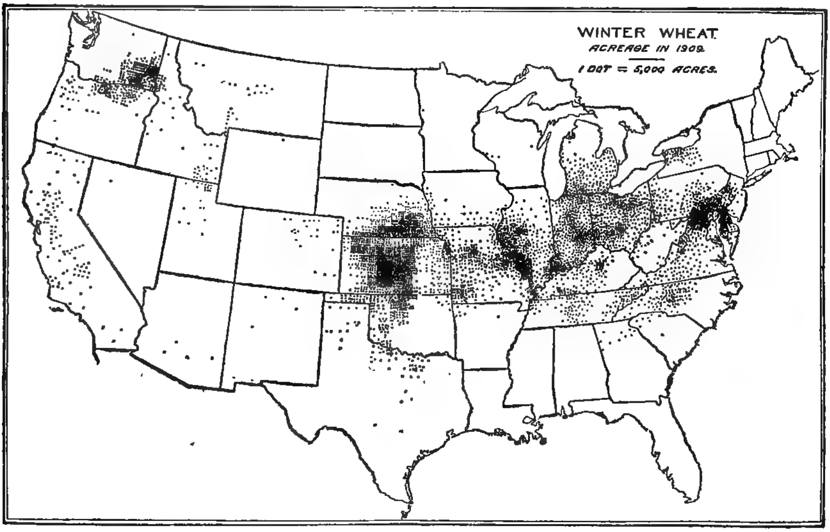

Fig. 41.—Winter wheat production. (U. S. Department of Agriculture.)

Spring and Winter Wheat.—Of the above states three grow spring wheat, Minnesota, North and South Dakota, while Nebraska and Kansas grow winter wheat. However, the division is not sharp, as a small acreage of winter wheat is now grown in the northern States, while some spring wheat, mostly durum, is grown in both Kansas and Nebraska. In the United States winter wheat production is still increasing, though spring wheat production apparently reached maximum about ten years ago.

Average production and yield per acre for 5 years, 1906–1910, was as follows:

	Production, bushels	Average yield per acre, bushels
Winter wheat	450,129,600	15.4
Spring wheat	243,186,800	13.5

The winter and spring wheat regions are shown by Figs. 40 and 41.

Advantages of Winter Wheat.—Winter wheat has several advantages wherever it can be grown: (1) It is more productive; (2) labor is better distributed; (3) where the land is seeded to timothy, the grass can be sown in fall. The principal limit to winter wheat culture has been winter killing (p. 128), but during the past twenty-five years the introduction of hardy varieties has rapidly extended the winter wheat area northward and westward into the drier regions.

Wheat as a Bread Crop.—In the United States there is an average of 5.5 bushels of wheat consumed by each person, in England about 6 bushels, in France about 8 bushels of wheat and 1 bushel of rye per person, and in Germany 3.5 bushels of wheat and 5.5 bushels of rye. More rye than wheat is also consumed in Russia, but in Europe, as a whole, about equal quantities of wheat and rye are consumed. While India produces considerable wheat, the quantity is small compared with her population. In India, rice, millet seed, and sorghum seed largely replace wheat as cereal food. Rice is also the staple cereal food of the people of China, Japan, and the East Indies.

QUESTIONS

1. How does wheat rank in value? Production?
2. Where is most wheat grown?
3. How does this compare with corn?
4. Is yield of wheat per acre increasing or decreasing?
5. In what kind of region is wheat usually grown?
6. Where is the Wheat Belt in the United States?
7. Compare with the Corn Belt.
8. Where is wheat acreage increasing? Where decreasing?
9. Is spring or winter wheat most important? Why?
10. How much wheat used per person in United States? France? Germany?
11. What are the other important cereals in the world?

CHAPTER XVI

ORIGIN AND DESCRIPTION OF WHEAT TYPES

Origin.—It is not possible to know how wheat originated as its culture dates back to the earliest recorded history. Specimens have been found in Switzerland, amid the ruins of the Stone Age. Chinese history shows it was an important crop 2700 B.C. and is one of the seeds that has been sown in their annual ceremony of sowing five kinds of seeds, from that day to this.

Related Wild Forms.—It undoubtedly came from some wild form that was very early brought under cultivation. There is a wild wheat-like grass in South Europe, the botanical name of which is *Egilops,* that some have thought to be a wild form. Recently a wheat has been found growing wild on the stony hills of Palestine, similar in many details to cultivated wheat.

Classification of Wheat.—Wheat has been an important crop for so great a time, and in every climate, that an unusual number of types and varieties have been developed. At least 1000 varieties have been mentioned and no doubt there are many more. Wheats are usually classed into eight species which may be grouped into three main classes.

I. *Bread Wheats.*—Grains free, ranging in color from white to dark red; stems hollow; grown mostly in temperate climates and regions of medium rainfall. Well adapted for making bread flour (Fig. 42).

1. Common wheat (*Triticum vulgare*) includes most of our common hard and red wheats.

2. Club wheats (*T. compactum*) generally soft; grown mostly on Pacific Coast.

Bread wheats are subdivided commercially as follows, according to degree of hardness and color:

Soft White Wheat
Soft Red Wheat
Medium Red Wheat
Hard Winter Wheat
Hard Spring Wheat

FIG. 42.—Bread wheats. Club wheat, common bearded (turkey) and common beardless (velvet chaff).

II. *Durum Wheat Group.*—Grains free; generally hard and flinty; stems pithy; grown mostly in dry and hot regions (Fig. 43). Used in manufacture of macaroni, etc.

3. Poulard wheat (*T. turgidum*) grain sometimes soft; head sometimes branched, as in the miracle variety.

4. Durum wheat (*T. durum*), very hard.

5. Polish wheat (*T. Polonicum*), large outer glumes.

III. *Spelt Wheat Group.*—Grains enclosed in glumes; grown some on poor, dry soils (Fig. 44).

6. Einkorn (*T. monococcum*), one-grained wheat; head compact.

7. Emmer (*T. dicoccum*), two-grained wheat; stems pithy; head compact.

8. Spelt (*T. spelta*), two-grained; head loose.

Bread Wheats.—In the United States about 95 per cent of the crop belongs to the bread wheats, 5 per cent is durum wheat, and only a small acreage of the spelt group. The regions of wheat production have already been outlined (p. 106). Bread wheats are classed as winter wheats and spring wheats, also as bald and bearded, but the most important grouping is the commercial grouping according to color and hardness of the grain.

Hard and Soft Wheat.—In general, the hard wheats are dark in color while the soft wheats are light. The soft wheats when cut in two show a white starchy interior, while hard wheats show no white starch, but, on the contrary, a dark, glassy texture.

In composition the soft wheats are much lower in gluten and make what is called a "weak" flour. In general, this means they do not make a large, heavy loaf of bread. Soft wheat flours, however, are preferred for certain purposes, as biscuit making or the manufacture of crackers, pies, and confections.

Hard wheats have more gluten and make a "strong" flour. Hard wheat flour is especially adapted for making light bread. The strength of flour is mostly due to the gluten, which not only makes the dough elastic but enables the bread to absorb more water, and therefore moister bread. Absorption of water also gives more pounds of bread. A hundred pounds of good strong flour will make 120 or more one-pound loaves. This is important to the baker.

FIG. 43.—Durum wheat group. Left to right, Macaroni, Polish and Poulard wheats.

FIG. 44.—Spelt wheat group. Left to right, emmer, spelt, and einkorn.

Wheat Regions.—The color and hardness of wheat is related to climatic conditions, the drier the climate the harder and darker the wheat, as a general rule. The hard wheats are raised mostly in the belt of states from Texas to North Dakota and including Minnesota. Hard winter wheat is raised mostly south of the boundary between Nebraska and South Dakota, while hard spring and macaroni wheat is raised north of this line (Fig. 45).

The soft wheats are raised in the more humid regions of the eastern and southern States, while semihard wheat is raised in the great middle region from Pennsylvania to the Missouri River.

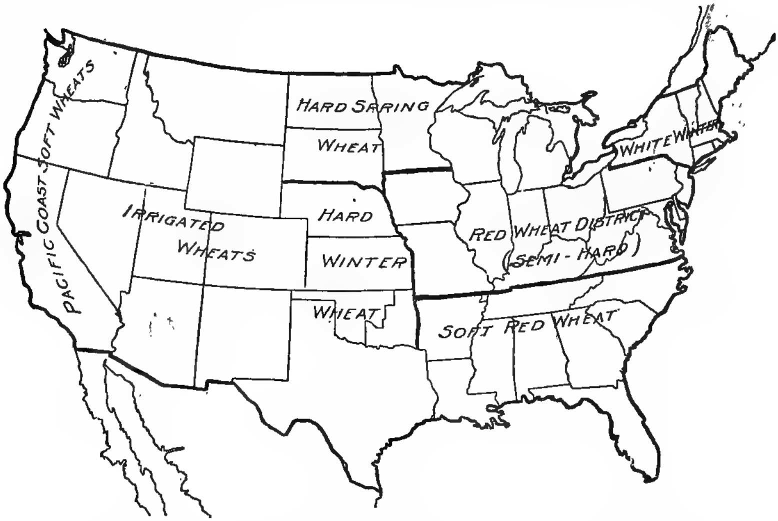

Fig. 45.—The principal wheat regions, according to type of wheat grown.

East of the Rocky Mountains we may say, in general, the quality of wheat is related to the humidity or dryness of climate. West of the Rocky Mountains, however, soft wheat is produced in a rather dry climate, but here it is also due to the climate and not to the soil. While climate affects the quality of wheat, the soil has little or no affect.

The Durum Wheat Group.—While the term "hard wheat" is applied to several of the bread wheats, it can only properly be applied to the durums, as these are much harder than the bread wheats. The

durum wheats are high in gluten and make a strong flour, but yellow in color, and produce a rather dark bread. Due to their high gluten content they are especially adapted to the manufacture of macaroni and other pastes requiring an elastic dough (Fig. 46).

Drought Resistance.—Durum or "macaroni" wheats, as they are commonly called, are especially adapted to grow in dry regions.

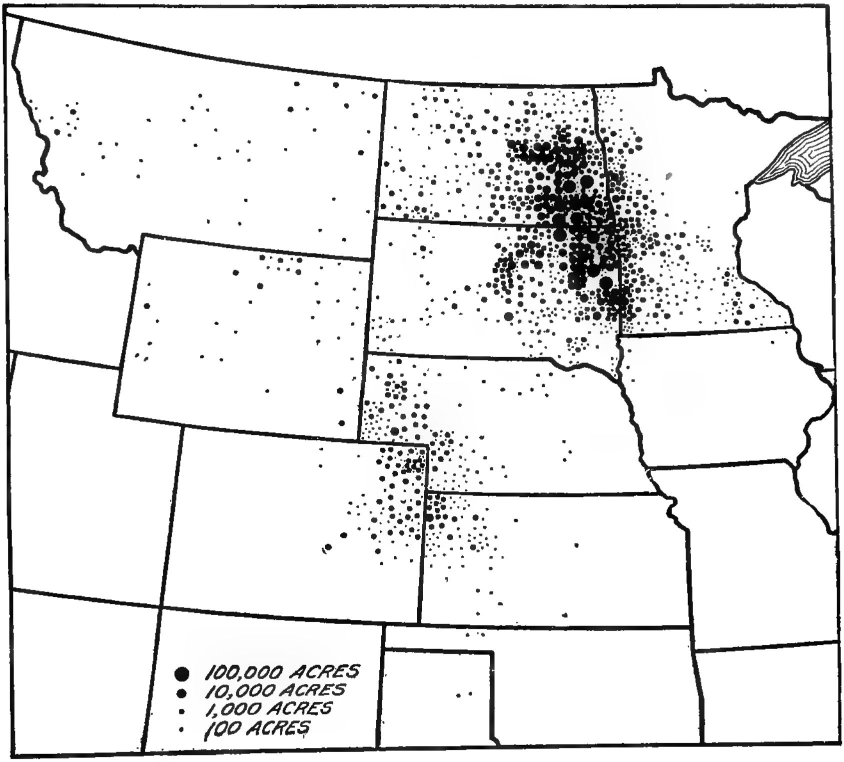

Fig. 46.—Distribution of durum wheat. (U. S. Department of Agriculture.)

They are largely grown in south Russia in a region with only 12 to 20 inches annual rainfall, and seldom make a good crop where the rainfall is over 25 inches. They are also the principal wheats of north Africa along the borders of the great Sahara Desert, where it is very hot and dry. They were generally introduced into the United States about 1900 by M. A. Carleton of the Federal Department of Agriculture, though a few varieties had been known here for many

years. They have found a place in the Great Plains region from the Dakotas to Texas.

Durum Wheat Types.—The Poulard is not a true durum as the grain is sometimes semihard and is grown in mild humid climates. In other respects it resembles the durums and can best be classed there. The " seven-headed " or " miracle " wheat is a type of this with branching head. It is grown very little.

Durum wheat or " macaroni " is the principal type in cultivation.

Polish wheat has a very long grain, sometimes one-half inch in length. The head also appears to be large, as the outer glumes are very large, the head sometimes being eight inches long and nearly an inch thick. It is not grown except in a very small way.

The Spelt Wheat Group.—In this group of wheats the grains are all tightly enclosed in the glumes as with oats. More or less of the grains are freed from the glumes in threshing, but not as a general rule. The grains are semihard, but make a rather poor flour. They are sometimes used as a meal by poor people in Europe. Their culture is nowhere extensive, but they are grown in a limited way and mostly on poor or dry soils throughout the south half of Europe. Their general introduction into the United States dates back to about 1900.

Einkorn is supposed to be the most primitive type of wheat, and probably one of the first in cultivation by man, not cultivated in America.

Emmer has probably the widest cultivation, and a number of varieties, the best known of which are white spring emmer and black winter emmer. The emmers have found a permanent place in the north half of the Great Plains, as a grain crop for stock feed. One variety, the black winter emmer, introduced by the U. S. Department of Agriculture, has been found to be especially adapted to the high elevated plains in Wyoming, Montana, and Colorado. The white spring emmer is cultivated in a limited way in the Dakotas and in Nebraska.

Spelt is not grown in America, though the name " speltz " is very commonly but wrongly applied to spring emmer. Spelt is cultivated some in western Europe, but not in Russia (compare Figs. 47 and 48).

How Varieties Originate.—During the past one hundred years a great many new varieties of wheat have been produced, in fact, most of the varieties now in cultivation have been introduced during the past sixty years. There are two methods by which most of these have been originated. The first is by selecting a single plant of unusual quality and increasing this until a supply of pure seed, all

FIG. 47.—Types of wheat grains. Top row, hard spring, hard winter, red winter. Bottom row, white winter, Polish wheat, durum.

from one plant, is obtained. The second method is to artificially cross one or more varieties, thus producing new types, and to select some desirable type from this cross.

Varieties by Selection.—Wheat lends itself to this method of improvement exceptionally well, as it is self-fertilized (p. 25). When a plant is found of superior type, it can be depended upon to produce plants true to type, without variation, for almost an indefinite period. This is in marked contrast to a cross-fertilized plant like corn or rye, which usually must be carefully selected for several years to fix a type.

Fig. 48.—Grains of spelt wheat group. In threshing, the kernels normally are not free from the chaff as in upper figures. Lower figures are the free kernels. Note that the kernels differ from wheat in being pointed at both ends. Left to right, einkorn, emmer and speltz.

Fig. 49.—An example of selection. Two plots of turkey wheat, each from a single plant. One lodged while the other stood erect.

Natural Occurrence of New Types.—It may then be asked how these new types are to be found in wheat if it does not vary. This is accounted for in two ways: (1) Occasionally a natural cross

does occur, and this breaking up will produce new combinations of characters. (2) It is believed that occasionally a "sport" or radical variation occurs, though we do not know the cause. At any rate, careful farmers have occasionally found superior plants growing in their fields, and by increasing these have secured new varieties (Fig. 49).

Examples of Successful Selection.—In 1862 Abraham Fultz, a Pennsylvania farmer, had a field of "Lancaster Red" wheat. Lancaster Red is a red-grained, bearded wheat, but he noted a plant without beards. This plant he selected and, sowing the seed in his garden, soon developed a variety which is known as Fultz wheat, and has for many years been the most extensively cultivated variety of red wheat in the United States.

In 1865 Garrett Clawson, a New York farmer, had a field of Fultz wheat, and found in this a few superior heads. Planting this the next year, both white and red wheat was produced, indicating that it was probably a natural cross. He secured a pint of the white wheat which the next year produced 39 pounds, and the third year after this 254 bushels were harvested. This wheat, known as "Clawson," was extensively cultivated in New York for many years and was distributed by the United States government.

Crossing Wheats.—In 1886, S. M. Schindel, a Maryland farmer, produced a cross of Fultz and Lancaster wheats, which is called "Fulcaster." It is a red bearded variety similar to Lancaster, and probably stands next to Fultz in extent of cultivation as a semihard wheat.

In other cases the hybrid wheats were recrossed several times before final selections were made. Two men who have given us many new varieties produced by crossing are C. G. Pringle, of Charlotte, Vermont, and A. N. Jones, of Newark, New York.

Winter and Spring Varieties.—Winter wheats differ from spring wheats chiefly in their ability to resist colder weather for longer periods. True winter wheats have what might be called a dormant period. That is, in order to accommodate themselves to winter conditions, they grow for only a few weeks and then remain without growth during the winter months, and resume rapid growth in the

spring. So fixed is this habit that when sown in the spring they remain for several months without "shooting" or developing stems, and if the weather is hot will probably fail to make stems at all.

There are, however, a large number of hardy wheats that do not have a true dormant period that may be sown in mild climates as fall wheats, but not in regions of hard winters. For example, in the Pacific Coast States Little Club and other hardy varieties are sown in fall or spring, but the winter is mild enough so that growth is not completely suppressed for a long time. These wheats can not be regarded as true winter wheats, since they develop normally when sown in the spring. In the same way, we find in the Gulf States that Burt Oats and several red varieties are sown in the fall and live through the mild winter, but farther north these varieties are sown in the spring.

EXERCISES

Study of Wheat Types.—The object of this exercise is to acquaint the student sufficiently with the different species of wheat, so they will be readily recognized, either when seen in the head or as threshed grain.

First take a head of common wheat and make a series of drawings, so that you may know all the parts.

1. Make two drawings (x2) of a short section of head: (*a*) from spikelet side and (*b*) from furrow side.

2. Remove spikelet and make enlarged drawing (x4).

3. Dissect spikelet, laying out all parts in relative position on a sheet of paper. Draw (x4) the parts and label carefully.

4. Draw a kernel (x4), labeling suture, cheek, brush.

5. Lay out in order, from left to right, one spikelet of each of the following types of wheat: (1) Einkorn; (2) emmer; (3) spelt; (4) macaroni; (5) Polish; (6) common smooth; (7) common bearded. Sketch each of these in order (x3).

6. Lay out kernels of each and examine. Draw a cross-section of each kernel, leaving white starch blank, but indicating vitreous portions by shading with pencil (x4).

State which of the types appear to normally have only two kernels per spikelet. In which are the grains enclosed in glume and in which are they free? Which have largest kernels? Smallest? How do the kernels appear to differ in color? Texture? Do the kernels of any type appear to be pointed at both ends? From your readings, state the principal use of each species. Where grown?

Descriptive Terms for Wheat.—Certain technical terms are used in describing wheat. This exercise is to give the student a little practice in the use of terms.

Having at hand a collection of wheat heads representing different varieties and species, look them over carefully, study the list of descriptive terms, and describe the heads by filling out blanks prepared according to form submitted.

Descriptive Terms

A. Spike:
1. Bearded, beardless, part bearded.
2. Shape:
   - Uniform—straight sides.
   - Clubbed—large at tip.
   - Tapering—tapering toward tip.
3. Cross-section:
   - Square.
   - Flattened on spikelet sides.
   - Flattened on furrow sides.
4. Spacing of spikelets:
   - Close, medium, wide.

B. Spikelet:
1. Broad, medium, narrow.
2. Number of kernels, 1, 2, 3, etc.
3. Glumes:
   - Hairy—smooth.
4. Color of chaff.

C. Kernels:
1. Color:
   - Clear red, dull red, whitish, amber.
2. Hardness:
   - Soft, medium, hard, very hard.
3. Texture in cross-section:
   - Starchy, part starchy, vitreous.

Descriptive Form for Wheat

Name of variety				
A. Spike:				
1. Beards				
2. Shape				
3. Cross-section				
4. Spacing of spikelets				
B. Spikelet:				
1. Width				
2. Number of kernels				
3. Glumes				
4. Color				
C. Kernels:				
1. Color				
2. Hardness				
3. Texture				

QUESTIONS

1. Give the early history of wheat.
2. How many varieties are there?
3. Name the important groups and state distinguishing characters of each.
4. Give principal use of each.
5. Which is most important?

6. Give principal distinction in a hard and a soft wheat in color; quality.
7. What is a "strong" wheat?
8. Give the principal wheat regions.
9. How does rainfall affect the quality of wheat?
10. What kind of flour do durum wheats make? Where grown?
11. When introduced into United States?
12. Describe the durum wheat types.
13. What are the spelt wheats like?
14. Where are they cultivated? What used for?
15. Describe various ways in which new varieties of wheat have originated.
16. Describe some good examples.
17. Define "winter wheat" and "spring wheat."
18. What difference between a true winter wheat and a wheat that may be sown either fall or spring?

CHAPTER XVII

WHEAT CULTURE

All the great cereal crops are grown by comparatively simple cultural methods. On clean, fertile soil, as the new prairie soils, little or no art is required to grow a crop. It is then simply a question of securing a variety adapted to the region, breaking the soil, sowing and covering the seed.

As a country becomes older, however, problems increase. Insect pests come sooner or later, plant diseases are apt to become more general, and the soil is depleted of fertility. As the new problems develop they are usually met in some degree, and the final system of cropping is an adjustment to changing conditions. Ordinarily the best and most thoughtful farmers of a community probably practice both practical and successful methods. The details of culture can best be found out by observation of successful farmers, and some experimenting with methods found successful in other places. In a text-book on culture only the most general principles can be dealt with.

Soils for Wheat.—Wheat has been in cultivation for a long time and at least some variety of wheat will grow on every productive soil, if it is properly prepared. There are at least two details, however, in which we may contrast wheat with corn and oats:

(*a*) Wheat is more sensitive to its surroundings and requires the fertility of the soil to be in a more available condition than does corn or oats. That is, if barnyard manure is applied or sod is turned under, it must reach a more thorough state of decomposition to produce a good effect on the wheat crop, as compared with corn or oats. In practice, it is much more common to grow corn, oats, or potatoes on a clover sod, or directly after manuring, than wheat. Also in practice, as soil becomes depleted the farmer generally begins applying commercial fertilizer to wheat before other cereal crops.

(*b*) Wheat, being more sensitive to its soil conditions, requires a more thoroughly pulverized soil, well compacted, than is the case with corn or oats. For example, in the Central States, where good oats are secured without plowing the soil in its preparation, but only

disking up well, and where corn land is plowed but often not thoroughly pulverized and packed, the same farmers practise much more thorough preparation of wheat land.

Soil Types Compared.—A loam soil or clay soil, not too compact, is usually said to be best for wheat, because it can most easily be brought into good tilth. However, good tilth can be secured on any productive soil, from a sandy loam to a heavy clay, by proper management, and good wheat is grown on all soil types.

In general, the heavier the soil the more thoroughly it must be plowed and pulverized; while in the sandier soil increasing attention must be given to a proper supply of organic matter.

Early Plowing for Winter Wheat.—Winter wheat is usually sown six to eight weeks before the ground freezes, which means sowing about the first half of September in the northern States and later as we go southward.

Experiments have been made at the Kansas, Michigan, Wisconsin, and North Dakota Experiment Stations, with early and late fall plowing. In every case where the plowing could be done from one to two months before seeding, the yield was considerably increased when compared with plowing and fitting the ground just before seeding.

The Compact Seed-bed.—One important reason for the improved yield from early plowing is that the seed-bed will be not only fine but firm. (1) A loose seed-bed will not allow proper root development, due to air-spaces, and (2) also it is apt to be dry. (3) The coarse, undecayed stubble and weeds turned down prevent good contact with the subsoil, so moisture does not readily pass upward. (4) Long experience has also shown that plants do not winterkill to so great an extent on a firm seed-bed, probably due to better root development.

Deep or Shallow Plowing.—In the western States there was a tradition more or less common for many years that plowing should not be deeper than the planting, so that the seed could be placed on the firm, undisturbed subsoil. There was good reason for this whenever the plowing was done just before planting, allowing no opportunity for re-compacting the soil. Experience has generally shown, where the plowing was done in sufficient time to allow for repacking (three or more weeks), that deep plowing (6 inches) was better than shallow (3 inches).

Uncertainty of Rules.—Cultural rules are very uncertain, since, in general, the crop is more affected by the kind of general management the land has had during the past ten or fifteen years than the particular kind of treatment given just preceding planting. The general effect of cropping systems on yield is developed in Chapter V, and should be here reviewed.

Fertilizers for Wheat.—In the older farming sections farmers begin applying commercial fertilizer to wheat before other cereal crops, as corn or oats. This is apparently because (1) wheat, being more sensitive to soil conditions, responds somewhat more quickly; (2) grass and clover are commonly sown with wheat and the fertilizer is often for the benefit of the new seeding also. The principles of fertilizing for wheat have already been fully developed (p. 36) and will not be further considered here.

Since fertilizers are to be used to supply needed mineral elements, it will be well to note the minerals most in demand by the wheat plant. Following is the average analysis, as reported by Laws and Gilbert, of the ash of wheat grain and straw:

Mineral Constituents of Wheat

	Grain	Straw
Ferric oxide	0.645	0.69
Lime	3.175	5.075
Magnesia	10.48	1.525
Potash	33.345	15.355
Soda	0.18	0.265
Phosphoric anhydride (P_2O_5)	50.065	3.10
Sulfuric anhydride (SO_3)	1.42	3.84
Chlorine	0.05	2.13
Silica	0.655	68.505
Total	100.015	100.485

Phosphoric acid and potash are by far the most important. In the grain phosphoric acid leads, while in the straw there is five times as much potash. The large silica content is not important, as the crop will do quite as well without it and the presence of silica in the straw may be considered more as a by-product. The other minerals in the list, except lime, are ordinarily present in abundance. Nitrogen is also added in fertilizers, but for wheat where a good rotation including clover is practised or manure is occasionally applied, only a little nitrogen is needed in the fertilizer.

On the wheat soils of the middle States phosphate is required

most, and many farmers in New York and Ohio use only acid phosphate, at the rate of from 100 to 300 pounds per acre. It is generally considered better practice, however, to use a complete fertilizer, which means all three elements. A common fertilizer for wheat contains 3 per cent nitrogen, 8 per cent phosphoric acid, and 5 per cent potash; such a formula is commonly known as a 3–8–5 fertilizer (see p. 37).

Minerals Used in Early Growth.—One reason which helps to explain why wheat responds so well to fertilizer is that it requires elements in the early part of the season when the available supply in the soil is limited. As the summer advances and the soil becomes warm, plant-food becomes more available, but studies at the Minnesota Station show that the wheat plant takes up about 85 per cent of its food supply from the soil by the time it is half-grown, while during the latter half of its growth wheat is building up its starch and cellulose material which is taken largely from the air. The following data on the wheat plant are reported in Minnesota Bulletin 29:

Composition of Wheat at Different Dates

Date	Condition	Dry organic matter per cent of total	Mineral matter per cent of total	Per cent of		
				N	P	K
May 10		...	...	...	...	...
June 30.	18″ high	44	74	86	80	75
July 15.	Headed	57	85	85	85	89
August 1.	Milk	90	100	98	100	95
August 20.	Ripe	100	99	100	94	100

Time of Sowing Winter Wheat.—It is generally agreed that the sowing should be early enough to give a good root growth before the soil freezes. This means six to eight weeks before freezing. If sown too early, however, the stems are apt to grow too large and to be killed back to the crown by freezing. This causes a second set of tillers to come out in the spring and these are never as strong as the first stems. Also, when the Hessian fly is present, sowing must be a little late to avoid the fly (p. 139).

Time of Sowing Spring Wheat.—The very earliest sowing possible is considered best for spring wheat. (1) The long period of

slow growth while the weather is cool gives a better root development, while if planted later it will shoot up quickly when warm weather comes. (2) Early sowing results in earlier ripening, which favors the avoidance of summer rust, and hot, dry summer weather.

Rate of Sowing Wheat.—At the Ohio Experiment Station wheat has been sown at rates varying from three to ten pecks per acre. In all, eight varieties have been grown. Following is a summary of several years' test with all varieties (Ohio Bul. 231):

Effect of Rate of Seeding

Pecks of seed per acre	3	4	5	6	7	8	9	10
Average yield per acre...........	23.6	25.0	25.6	26.6	26.8	27.7	27.9	27.5
Net yield when seed is subtracted.	22.9	24.0	24.4	25.1	25.1	25.7	25.7	25.0
Average weight per bushel.......	58.6	58.8	58.7	58.9	59.0	58.9	59.0	59.0

These data show only a small increase in yield due to heavy seeding. When wheat tillers well and no severe loss from winter-killing occurs, 4 pecks will give a full stand, but long experience has shown that it is safer under average conditions to sow rather thickly. On heavy clay soils where wheat does not tiller freely, more seed is required than on warmer or lighter soils. Eight pecks is recommended for Ohio while farther west, along the Missouri valley, five to six pecks are usually sown. Farther west in the dry farming section (western Nebraska) three to four pecks is the usual recommendation. Here wheat not only tillers freely, due to the warm loose soil, but with the low rainfall, thin sowing with larger plants will endure drought better.

Broadcast Sowing vs. Drilling.—Three reasons are usually advanced in favor of drilling (Fig. 50): (1) Better germination. When grain is sown broadcast only a part is covered at the proper depth to come up at once. This results in uneven growth and some plants are too late to make their best yield. (2) Withstands winter-killing better. The crowns are better protected, and when the ground heaves through freezing, the mass of plants in a drill-row are not so easily thrown out of the soil. (3) When grass or clover is sown with the wheat it will do better, as it can grow between the drill-rows and gets more light.

Winter-killing.—Winter-killing is a source of large loss to the wheat growers. The United States Department of Agriculture reports every year the acreage abandoned due to winter-killing. The percentage abandoned for 11 years is shown as follows:

Year	Percentage	Year	Percentage
1901	6.7	1907	11.2
1902	15.2	1908	4.2
1903	2.8	1909	7.2
1904	15.4	1910	13.3
1905	4.6	1911	9.0
1906	5.5		
		Average	10.5

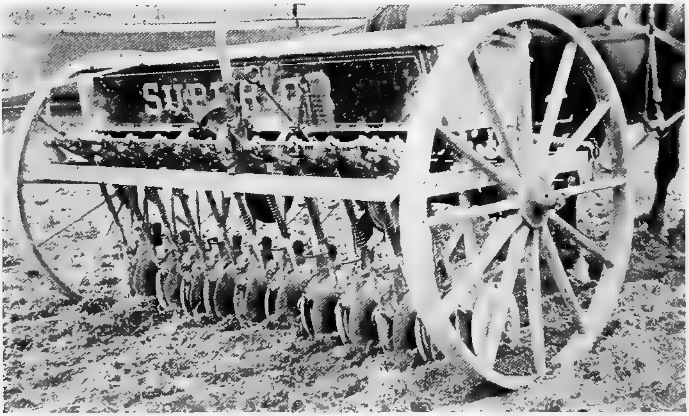

Fig. 50.—Drilling wheat with a double-disk drill.

Winter-killing is due to several causes: (1) Heaving out by freezing of soil. All heavy soils in humid regions heave, due to alternate freezing and thawing. This breaks the wheat roots and throws the plants out on the surface. (2) Winter drying. In the Great Plains region the soil is often dry all winter with no snow covering. Large cracks develop and the plants are slowly dried out, especially on loose or poorly prepared soil. (3) Late sowing on poor soil, when the plants are so weak they kill by direct freezing.

Seed Wheat.—While every grower should always be on the lookout for new or improved varieties, he should, in the main, grow the variety that long experience has shown to be best for his region, and try the new varieties only experimentally.

As wheat is a self-fertilized plant and therefore is not easily influenced or changed, we can not expect a stock of wheat to materially improve or degenerate from year to year. This would be especially true if the wheat were all of one fairly pure type. However, if the wheat is a mixture of types, then we should expect those types best adapted to produce the heaviest and best grains. If the difference in weight is sufficient, a rough separation can be made with a fanning mill; but if the difference in weight is not great, we have no machine sufficiently sensitive to make a separation.

Size of grain where all are well developed is not important, as large and small grains come from the same head and carry similar hereditary characters.

We may, therefore, conclude that if the seed wheat is sound and of good weight, there is probably no good reason to expect further improvement by fanning or grading; but if there is a noticeable portion of light seed, it would be desirable to grade. Impurities, as noxious weed seeds, should always be removed.

Changing Seed.—It is a more or less common belief that a variety will run out if grown for a long time in one place. Rather extensive trials were made by the North Dakota and Minnesota stations. Seed of the same varieties was exchanged between these States, in all 23 trials, with the result that in no case was the change an advantage and the average showed a decrease of 2.5 bushels per acre, when the seed from the other station was compared with home-grown.

Home-grown Seed at Ontario.—At the Guelph Station, Ontario, Canada, certain varieties of cereals have been continuously grown for many years, and in all cases there has been no apparent decrease in yield, but, on the other hand, all the varieties appear to yield better now than before.

Cultivation of Wheat.—In Europe in certain regions where labor is cheap and farming intensive, small grain is cultivated by hoeing between the drill-rows. In ordinary practice, however, no culture is given after the grain is sown.

Going over the fields with a peg-tooth harrow or weeder is practised in some parts of the wheat belt, and is considered good practice in dry years. To use the harrow the plants should be drilled, and

then the drill-rows followed, not crossed. The plants should be well rooted before using the harrow, but not too large. It is not practical to harrow broadcast grain.

Rolling in the spring is very often good practice. Rolling settles the soil about the roots and fills up the cracks. At the Nebraska Station rolling increased the yield about 5 bushels per acre during a period of several years (Nebr. Bul. 104). In the eastern States when grass and clover seed is sown in the wheat, rolling is considered beneficial to the new seeding. Corrugated rather than smooth rollers are generally considered best.

Pasturing Wheat.—In the southern part of the wheat region, from Kentucky to Oklahoma, considerable fall and winter pasture can be secured from the wheat fields. Properly managed the crop will not be much injured. Under certain conditions it is said to be beneficial, as a very open fall when the wheat makes a heavy top growth and is in danger of winter injury. Also when the soil is very loose, tramping by cattle may be beneficial. However, as generally practised it is to be condemned, as the wheat is frequently eaten down very close and cattle are allowed on when the land is wet.

Summer Fallow for Wheat.—Summer fallow usually means to plow and cultivate a piece of land for an entire summer without a crop. The method has been practised in a limited way in all climates and soils on poor land, but is only found as a regular practice in somewhat dry regions. This method gives a crop only once in two years, hence the yield must be more than twice as great to be more profitable. In general, experiments have failed to show an average double yield for summer fallow, except in the very driest regions. Further, almost as good results are secured in the wheat crop if a cultivated crop, like corn, is raised in the year when fallow would ordinarily be practised. However, in some regions where very extensive farming is practised with big machinery, the land will get very foul with weeds, and in such cases it is advised that summer fallowing once in four years is the most practical way of clearing the land of weeds and of putting it again in good physical condition.

The Listing Method.—This method is also practised in dry regions under extensive farming methods. The method consists in

breaking the land immediately after wheat harvest with a lister, or double mould-board plow, in furrows three to four feet apart. When weeds have started, the soil is worked into the furrows with a corn cultivator, or only harrowed. The land may be leveled with one cultivation and harrowing, but it is better to level in two cultivations, and one, two, or more harrowings with the disk harrow and peg-tooth harrow. Advantages claimed for this method are: (1) That the land can be quickly and cheaply broken after harvest, thus conserving moisture. (2) That rainfall is more effectively taken up and conserved. The rain, collecting in the furrows, reaches the subsoil at once, and if loose soil is filled in soon after, the water is well protected by the loose mulch. (3) The method is low in cost as compared with other methods that fit the soil as well and conserve the moisture.

QUESTIONS

1. What is a good way to find out practical methods of wheat culture?
2. Compare wheat and corn as to manurial requirements; preparation of the soil.
3. Explain importance of early plowing for fall wheat; of a compact seed-bed.
4. Compare deep and shallow plowing.
5. Why are cultural rules uncertain?
6. Give apparent reasons for fertilizing wheat before other farm crops.
7. What are the most important mineral elements in the grain of wheat? Straw?
8. Is silica important?
9. Which element is most important in wheat fertilizers?
10. Explain the assimilation of minerals and carbon in different periods of growth.
11. Give principles governing time of growing winter wheat. Spring wheat.
12. Explain relation of rate of sowing to tillering; yield.
13. What is the usual rate of sowing in your neighborhood?
14. State the advantages of drilling over broadcasting.
15. To what is winter-killing due?
16. How serious is it in winter wheat culture?
17. Why is wheat fairly constant in character?
18. When may we expect fanning seed wheat to be good practice?
19. Is changing seed good practice?
20. Compare harrowing and rolling as treatments for growing wheat.
21. Is pasturing fall wheat practical?
22. Compare the advantages and disadvantages of summer fallow for wheat.
23. Describe the listing method.
24. Where is it practised?

CHAPTER XVIII

HARVESTING, MARKETING, AND UTILIZING WHEAT

Harvesting.—While some have advocated cutting wheat green, it is now generally agreed that wheat should be well ripened to secure maximum yield. As the roots and lower part of the stems appear to die first, there probably is no loss if cut when the upper stems are slightly green. Disadvantages of overripeness in humid climates are: (1) wheat shatters more; (2) in the hard wheats, overripe wheat will have more "yellow" berries, which injures the milling value.

On the Pacific Coast wheat is allowed to stand several weeks after ripe. This is possible because there is no rain during this season. Varieties are used that experience has shown will stand up for so long a time and that are also non-shattering. This makes possible the use of the combined harvester and thresher, the whole operation being completed in the field.

Shocking.—Where grain is to be hauled to the barn, as is the universal custom in the Eastern States, or stacked at once it is desirable to have rather small and loose shocks, so the grain will cure out rapidly. In such cases it is even doubtful whether the shock should be covered with a cap, unless the harvest season is rainy.

When the grain is to be threshed from the shock and may remain in the field for two or more weeks, considerable skill is required to make good shocks that will not blow over and will also shed rain. In this case the shocks should be rather large, 12 to 16 bundles, and two cap sheaves. Round shocks with the heads well drawn in will be better than long shocks. Generally, grain shocks are very poorly put up, but a good, large, well-made shock will stand for several weeks and suffer little damage to the grain.

Threshing from Shock or Stack.—If the weather is dry and the grain can be threshed at once from the shock without exposure to rain, the grain will be secured in good condition. Exposure to rain, however, will ordinarily cause loss in both quality and yield. In Minnesota data have been collected showing that it costs about one

cent per bushel more to stack and thresh, as compared with shock threshing. The extra expense was considered as cheap insurance against greater loss, in case a machine was not available for threshing as soon as the grain was ready.

Cost of Producing Wheat.—The cost will vary on every farm, due to a large number of factors. The following table on cost of production in the United States will give a general idea. The first three columns of figures are taken from the Crop Reporter for May, 1911, and the last two are calculated from the Census data. The figures all apply to the crop of 1909.

Cost of Raising Wheat

Section	Acre value	Acre cost	Value less cost	Yield per acre	Cost per bushel
	Dollars	*Dollars*	*Dollars*	*Bushels*	*Cents*
North Atlantic	21.18	17.05	4.13	17.9	95
South Atlantic	16.83	13.10	3.73	11.8	111
South Central	14.05	10.35	3.70	11.3	91
East North Central	18.31	13.41	4.90	16.6	81
West North Central	14.96	9.74	5.42	15.2	64
Far Western	22.01	12.69	9.32	22.9	55
United States	16.48	11.15	5.33	15.8	75

Shrinkage in Storage.—Wheat grain is usually much drier than corn when stored. While corn may be expected to shrink 5 to 20 per cent during the first year in storage (p. 85), wheat is expected to shrink not more than 2 to 3 per cent.

Market Grades.—A large portion of the wheat crop is sold directly to the local miller or dealer and is then bought on inspection of the grain. Where grain is shipped to the great terminal markets, as Chicago, Minneapolis, or St. Louis, it is graded by official inspectors, who are usually employees of the State. The grain is bought and sold according to these grades.

The grades recognized by the Grain Dealers' National Association are as follows:

White Winter Wheat, Nos. 1, 2, 3, and 4.
Red Winter Wheat, Nos. 1, 2, 3, and 4.
Hard Winter Wheat, Nos. 1, 2, 3, and 4.
Northern Spring Wheat, No. 1; Hard Spring, Nos. 1, 2, 3, and 4.
Spring Wheat, Nos. 1, 2, 3, and 4.

Durum Wheat, Nos. 1, 2, 3, and 4.

Pacific Coast Red Wheat, Nos. 1, 2, 3, and 4.

Pacific Coast White Wheat, Nos. 1, 2, 3, and 4.

There is also a grade in each case known as "rejected," which means the wheat was too poor, too wet, or for any other reason not fit to grade.

In general, a No. 1 wheat should weigh 60 pounds or more, a No. 2 wheat 58 pounds, a No. 3, 56 pounds, and a No. 4, 50 pounds or more.

EXERCISES

To Determine Weight per Bushel.—In measuring grain the measure is filled level full and stroked with a straight edge, instead of heaping the measure as with apples or potatoes.

In practice the weight is usually determined by the use of a one-quart or two-quart brass kettle, hung on a weight beam.

In filling the kettle it is the custom to pour the grain in loose as possible, then, without shaking, stroke with straight edge.

Try different methods of filling to note effect on results, as dipping the kettle, filling loose, and shaking, or pouring in grain at different heights.

WHEAT JUDGING

By referring to the text it will be noted that the common wheats may be grouped into five classes, according to color and degree of hardness. This should be thoroughly reviewed before taking up the exercise.

Materials.—Threshed lots of wheats representing hard winter, hard spring, red wheat, white wheat, and durum wheat; also a set representing official grades and miscellaneous samples collected from local sources.

Sampling.—First mix grain thoroughly and dip out about a teaspoonful. Some prefer to use an even 100 grains in a sample, as it avoids figuring percentages, but this is not important as percentage is easily calculated. Also a chance sample is likely to be more fair than a counted sample.

Method of Analysis.—*Weight per Bushel.*—This should be determined if apparatus is available for doing so.

Purity and Soundness.—Foreign matter and broken or injured seeds may be classed together, as they must all be removed to find net weight of good grain.

Injured grains are of four classes:

1. Bin burnt and stack burnt means wheat overheated in bin or stack, causing the oil to exude and giving a dark appearance to the germ end.
2. Sprouted grain. Generally shows dried sprout.
3. Broken grain.
4. Shriveled grain, due to arrested development in growth, from such causes as disease, insects, or unfavorable weather.

(Having discarded impurities and unsound grain, use sound sample for rest of exercise.)

Texture and Hardness.—In general the wheats from the drier regions are classed as "hard" wheats, while those from humid regions are classed as "soft" wheats. There is a large intermediate class, known on the

market as "red" wheats. In general the harder wheats are darker in color (the durum wheats an exception) and higher in protein content. The hard wheats make a "strong" flour adapted to light bread making, while the soft wheats produce a "short" and "weak" flour adapted to biscuits or cracker making.

Color of Kernels.—As already explained, color is related to hardness. The "amber" and "clear red" wheats are those with a glassy, translucent appearance when broken, and hard texture. Most hard wheats are clear red in color, but the durum wheats are an exception, being "light amber." The "dull red" wheats, known as "red" on the market, are medium hard, but white and starchy when broken. The "white" wheats are softer and pure white inside when broken.

Size of Kernels.—This is arbitrary but is determined by comparison with various samples of wheat of types representing the various sized kernels.

Report on Wheat Samples

(Express data in per cent)

	1	2	3	4	5	6	7	8
Weight per bushel	....	....	....	....	....	....	....	....
Purity and soundness:								
Foreign matter	....	....	....	....	....	....	....	....
Broken grains	....	....	....	....	....	....	....	....
Shriveled grains	....	....	....	....	....	....	....	....
Otherwise damaged	....	....	....	....	....	....	....	....
Texture and hardness:								
Hard and vitreous	....	....	....	....	....	....	....	....
Medium	....	....	....	....	....	....	....	....
Soft and starchy	....	....	....	....	....	....	....	....
Color of kernels:								
Light amber	....	....	....	....	....	....	....	....
Clear red	....	....	....	....	....	....	....	....
Dull red	....	....	....	....	....	....	....	....
Whitish	....	....	....	....	....	....	....	....
Size of kernels:								
Large	....	....	....	....	....	....	....	....
Medium	....	....	....	....	....	....	....	....
Small	....	....	....	....	....	....	....	....
Weight of 100 grains	....	....	....	....	....	....	....	....

Score Card for Wheat

	1	2	3	4	5	6	7	8
Weight per bushel............30	....	....	....	....	....	....	....	....
Purity and soundness.........30	....	....	....	....	....	....	....	....
Uniformity in:								
Color.....................10	....	....	....	....	....	....	....	....
Texture...................25	....	....	....	....	....	....	....	....
Size of kernel.............. 5	....	....	....	....	....	....	....	....

EXPLANATION OF CUTS

1. *Weight per Bushel.*—30. Good wheat should weigh 60 lbs. per bushel. Cut 2 points for each pound below this.

2. *Purity and Soundness.*—30. Cut two points for each per cent foreign matter or broken and unsound kernel.

3. *Uniformity in Color.*—10. Let the bulk of the sample determine the color. Cut 2 points for each per cent of other colors.

4. *Uniformity of Texture.*—25. Cut two points for each per cent of texture not uniform with bulk of sample.

5. *Uniformity in Size.*—5. Cut 1 point for each per cent of small sized grains.

Written Report on Wheat Judging.—Make a written report of about two or three pages, answering these questions. For reference see lecture notes and reference books.

1. What is meant by "texture" as applied to wheat kernels?
2. How is it related to color—to composition?
3. How is texture affected by climate and soil?
4. Why does the miller prefer plump kernels for milling?
5. Why does the miller object to cracked, bin burnt, and sprouted kernels?
6. What is the difference in color and quality of flour from hard and soft wheats?

QUESTIONS

1. What is the proper time to cut wheat in humid regions?
2. Give the different practices on the Pacific coast.
3. What are the different practices in shocking grain?
4. Compare threshing from shock or curing in stack.
5. How does cost of production vary in the United States?
6. Compare shrinkage of corn and wheat in storage.
7. What are the principal market classes?

CHAPTER XIX

DISEASES AND INSECT ENEMIES

THE three wheat diseases causing most damage are, in probable order of importance, rust, smut, and scab.

Rust.—Rust is found in all wheat regions, but is most injurious in the humid regions. In dry seasons the damage is usually not great, but occasionally in a wet season will cause almost complete loss of crop over large areas. While all rust has similar appearance on the plant, there are really two kinds—the leaf rust or "red rust" and the stem rust. Stem rust is most destructive. It may live over winter on old stubble, or straw, and probably on young winter wheat plants. The growing wheat may be affected at any time, but usually weather conditions are most favorable about two or three weeks before the wheat is ripe. There are no known remedies for rust except to choose rust-resistant varieties, as varieties vary in this respect.

Smut.—There are two kinds of wheat smut. The most destructive is known as bunt, or stinking smut, and the other as loose smut. They differ in these respects: (1) The bunt destroys only the kernel, leaving the glumes intact, while loose smut destroys both grain and glumes, leaving only a bare rachis. (2) When mature the spores of the bunt usually remain intact in the grain, making the characteristic "smut balls" found in the threshed grain. The loose smut breaks up and the spores are scattered while the grain is standing.

Infection.—It is important to note the difference in infection of the two smuts and the resulting different method of treatment necessary. (1) The bunt smut balls are broken up more or less during harvesting and threshing and the loose spores find lodgement on the outside of grains and remain on the *outside,* especially among the hairs at the upper end or in the crease. (2) The loose smut matures at about the time the grain is in blossom. The spores are at once spread, and, lodging on young seeds just forming, germinate and penetrate to the *inside* of the seed, where the smut remains dormant until germination.

In both cases the smut begins to grow when germination of the wheat begins and at once infects the plant, living inside the tissues. The infected plants are not noticed until heading time when the heads turn into smut. The infected plants are usually shorter and not so noticeable, so that the damage by smut from a casual observation is usually underestimated.

Treatment of Seed.—Since the disease is carried over from year to year on the seed, treatment consists in using some disinfectant that will destroy the smut but not injure the wheat germ.

(1) *Bunt* spores are on the outside of the grain and are easily killed by treating the seed with a solution of formalin. Use one pint or pound of 40 per cent formalin solution in 40 to 45 gallons of water. The wheat may be put in loose sacks and placed in the solution to soak for 5 minutes. A simpler way is to pile the wheat on a floor or in a wagon box, and apply the solution with a sprinkling can, shoveling the grains over until all are thoroughly wet. While the spores should be killed by contact with the solution, the treatment is considered much more effective if the grain is piled up and covered with wet blankets or sacks for 12 to 24 hours. The formaldehyde gas will then have time to penetrate all crevices of the grain and to destroy the spores.

Loose smut, having infected the seed in the field while very young, is found *inside* the seed in the form of a small filament. No treatment for the outside of the grain will kill it. The only effective method is known as the hot-water treatment, which rests on the principle that the smut filament is killed by a temperature of 130° F. while the wheat germ will stand four to five degrees higher temperature. First soak the seed for four to six hours in cold water. Have ready two tubs of water heated to 133° F. and place the grain in a loose sack in the first tub, to bring up the temperature. Then place in the second tub, keeping the temperature not lower than 129° F. or higher than 133° F. Five minutes at 133° or 10 minutes at 129° will kill the smut. Germination of the seed is also likely to be injured and more should be sown. As the treatment is slow it is best to treat only enough for a seed plat. With clean seed and care, another treatment may not be necessary for several years. The smut is often spread by itinerant threshing machines.

Scab.—Wheat scab is a mold (*Fusarium*) that affects the wheat head. Only a part or all of the head may be affected. It will be recognized by the reddish spot at the base of the affected glumes. There is no known remedy, but it is best to get clean seed and not use seed from an infected field.

Insect Enemies.—All wheat insect enemies are quite irregular in their attacks. This seems to be due, in turn, to the enemies of the insects that keep them more or less controlled. The "green bug," a plant louse, is a good example. This insect is to be found on wheat every year, but is seldom injurious, as its natural insect enemies are usually so plentiful that it is kept in subjection. Occasionally, however, the enemies are outdistanced and the green bug increases at an enormous rate, often doing great damage for a season. Weather, also, favors or hinders insects, and it is only when we have a combination of favorable conditions that they are usually very destructive.

The principal insects are (1) Hessian fly, (2) chinch bug, (3) green bug or plant louse, and (4) wheat midge. Of these the Hessian fly and chinch bug are favored by dry weather and the wheat midge by moist weather.

Hessian Fly.—The Hessian fly is a small two-winged insect. In most of the winter wheat belt it produces two broods a year, the first in August and September and the second during May and June, being earlier South. The fall brood lays eggs on the leaves of the new fall-sown wheat. In three to ten days, depending on the weather, the eggs hatch and a small worm or *larva* emerges. The larva attacks the plant just below the surface of the ground. A single larva will injure a plant and three or four may kill it. The damage is somewhat regulated by the vigor of the wheat. The larva soon goes into the pupa or "flax seed" stage, when it looks like a small, brown flax seed attached to the stem under the first leaf sheath. It remains in this state until the following May when the second brood is hatched.

Frost will kill either the insect or its eggs, and it can be controlled by late planting. If planting can be regulated to come about two weeks before the first frost, there will be little danger from the fly.

Whenever the fly is noted as present at harvest time, late planting should be practised that fall.

Chinch Bugs.—Chinch bugs are favored by dry climate, and are seldom injurious east of the Mississippi River. Two or three dry seasons in succession will favor their rapid increase. Chinch bugs harbor in stubble, grass clumps or in weedy fence-rows during the winter. If grass is kept down by clean culture, stubble plowed under, and fence-rows fired late in the fall, the bugs can, in a measure, be controlled.

The Plant Louse.—The louse generally is found on the wheat in the fall. If conditions are favorable the following spring it may increase at an enormous rate. It is rarely injurious and no control measures have been proposed.

The Wheat Midge.—This is a small two-winged fly that lays its eggs on the glumes of the wheat head at about blossoming time. The larva sucks the juice from the young wheat grains, causing them to shrivel up. The pupa passes the winter in the soil near the base of the wheat plant. No control measures are proposed except deep fall plowing.

QUESTIONS

1. Describe rust in appearance and method of spreading.
2. Distinguish between the two kinds of smut as to difference in appearance.
3. In mode of infection; in treatment.
4. Why are insect enemies so irregular in attacks?
5. Give life history of the Hessian fly. Method of control.
6. Give control of chinch bugs.
7. Describe work of the wheat midge.

CHAPTER XX

OATS

OATS are the fourth crop of importance in the world, being exceeded by potatoes, corn, and wheat. (See charts, Chapter I.) In the United States it is the third cereal, being exceeded by corn and wheat. Oats are a northern grown crop adapted to humid regions. East of the Mississippi River and north of the Ohio, oats outrank wheat in value, and in several of the Northern Tier outrank both corn and wheat.

Production of Oats.—The oat crop of the world for the 5-year period, 1906–1910, is shown by the following table, as reported by the 1910 Yearbook, United States Department of Agriculture:

Continent	Bushels
Europe	2,475,031,000
North America	1,227,061,400
Asia	86,226,600
Australasia	27,954,000
Africa	17,835,000
Total	3,834,108,000

The principal oat-producing countries (Fig. 51), together with the average yield per acre for two decades, is shown in the next table:

Six Countries Leading in Oat Production

Country	Average yield for 5 years 1906–1910	Average yield per acre	
		1890–1899	1900–1909
	Bushels	*Bushels*	*Bushels*
United States	932,124,400	26.1	29.3
Russia	852,765,000	17.8	20.0
Germany	582,867,000	40.0	50.7
France	298,597,000	29.8	31.6
Austria Hungary	246,253,000	25.3[1]	30.2
United Kingdom	185,867,200	43.6	44.3
Total	3,098,473,600		

The six countries produce about four-fifths of the world's crop. It will be noted with interest that in every case the yield per acre

[1] Austria only for 1890–1899.

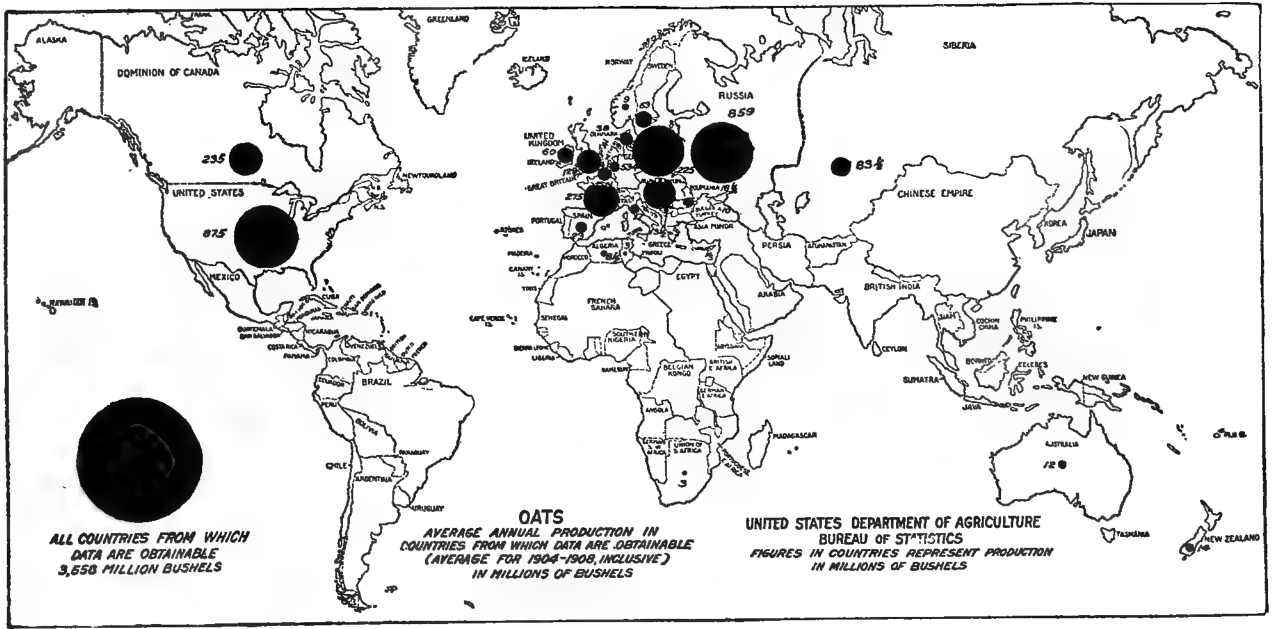

Fig. 51.—Distribution of oat production.

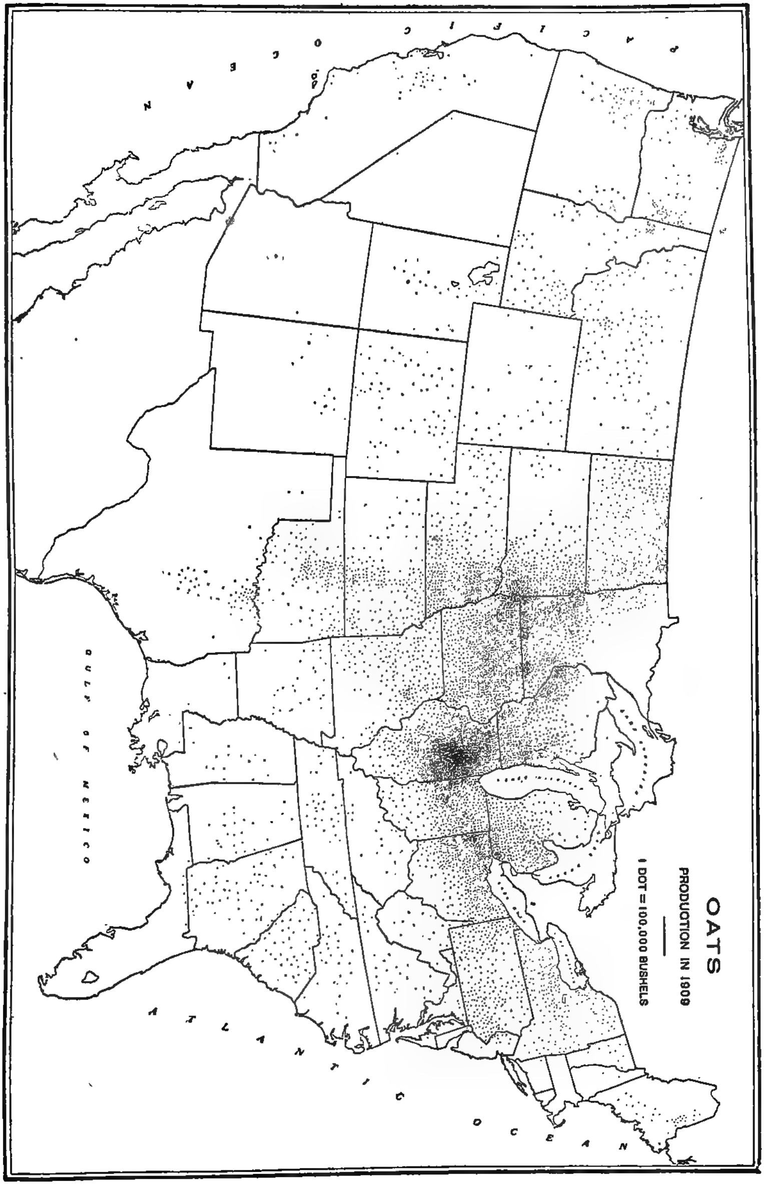

FIG. 52.—Distribution of oat production in the United States. (From U. S. Census, 1910.)

has increased during the second decade. The average yield in both Germany and England is comparatively high, while the two greatest oat-producing countries, United States and Russia, have rather low yields per acre.

FIG. 53.—Loose type of side panicle variety, sparrow-bill.

In the United States (Fig. 52) and Russia, with great level plains and rather low rainfall, the farming is at present extensive rather than intensive, as in Germany and England. With the best methods of farming the present average yields in the United States could be doubled, and at present the movement is in that direction.

Oats in the United States.—About twice as much oats are raised in Europe as in North America. In the United States the oats region consists of six adjacent States, namely, Illinois, Iowa, Wisconsin, Minnesota, Nebraska, and Indiana, in the order named.

FIG. 54.—Compact side oats, and open type of semiside oats. Varieties, Clydsdale and Black Finnish.

The six States produce 55 per cent of the oat crop, but Illinois and Iowa far exceed the others.

While oats as a crop appear to reach their highest development in quality and yield somewhat north of the Corn Belt, yet they are

extensively raised in the Corn Belt as a crop to rotate with corn. The actual value of oats per acre is not so great as winter wheat, but oats are much more convenient as a crop to follow corn, and the grain and straw are both much needed by the farmers as stock feed.

Early History.—While wheat and barley appear to have had a very ancient origin, and were cultivated from earliest times, little is apparently known of oats until about the Christian era. It seems to have originated as a cultivated plant in eastern Europe, and its culture remained principally in temperate Europe until the discovery of America. Pliny, in the first century, wrote that the Ger-

Fig. 55.—Types of oat grain. From left to right: short, thick grain of black oats; large white oats, variety Big Four; long grain early oats, variety Burt; small grain early oats, variety Kherson.

mans lived on oatmeal, and it has always been of some importance for human food in Europe, though for many centuries it has been recognized as the best of all cereals for horses.

Classification of Oats.—There are at least 400 to 500 varieties of cultivated oats and they may be classed into several natural groups (Figs. 53, 54, 55, 56 and 57).

Shape of Head.—In the *spreading type* of panicle the head is usually upright and the branches equally distributed on all sides. In *side oats* or "horsemane" oats the head is usually drooping and the branches on one side (Fig. 53). There may be found all intermediate types between the extreme shapes.

In the *compact* panicle the branches are usually shorter and clustered near the central stem, while in the *open* form the branches are usually longer and more flexible (Fig. 54).

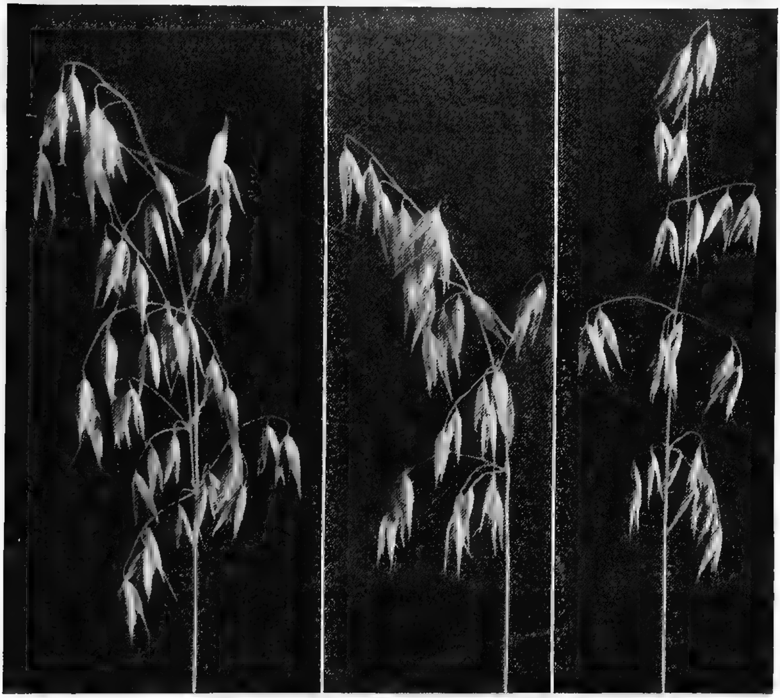

FIG. 56.—Three types of early oats, of open panicle type. Left to right, Sixty Day, Burt and Texas Red.

Color of Grain.—There are five principal colors which may, for convenience, be grouped in the following manner:

Group	Characteristics
White oats	Grains usually rather large and plump.
Black oats	Well adapted to north temperate climates, as Canada, but not suited to south temperate climates, as the Gulf States.
Red oats	Grains long in shape, reddish, brown, yellow, or grayish in color.
Yellow oats	While doing well in the temperate climates, they are much better adapted to south temperate climates than the black and white oats.
Gray oats	Several winter varieties in this group.

Distribution of Groups.—White oats are the most commonly cultivated oats north of 45° latitude in Canada and the northern tier of states in the United States. The varieties of white oats are practically all medium to late in maturing. Hardly a variety of early oats may be strictly classed as white oats. Black oats varieties are generally similar to white oats except in color.

The varieties of red and yellow oats are undoubtedly better adapted than white or black oats to south temperate climates, as the region south of the Ohio River. Several varieties are adapted to fall or winter sowing in the South, and are known as winter oats.

Between the two regions just described lies a large territory (the Corn Belt) where it is something of a question just which group will give best results. White oats are generally grown, though they only occasionally attain the good quality of the white grown farther north. The great limiting factor in this region is the coming of dry summer weather before the oats mature. This gives the early maturing varieties a distinct advantage, and throughout the Corn Belt the early yellowish varieties, as Kherson, Sixty Day, or Burt, are rapidly gaining in favor.

Spring and Winter Oats.—All the oat crop north of the Cotton Belt is spring sown. It is also sown in spring in the Cotton Belt, but does not yield so well as fall-sown oats. The fall-sown varieties are mostly not strictly winter types, as the same varieties are sown as spring oats farther north. They are hardy enough to withstand the mild winter and continue growth slowly. They ripen much earlier than spring-sown oats, thus avoiding in a degree the severe summer rust. The red varieties are often called " rust proof " oats.

Virginia Grey or Turf oats are true winter oats, requiring a long latent period after sowing, and will not produce a crop when sown in spring.

Early and Late Oats.—In general, varieties of oats will vary from 95 to 120 days to mature from time of sowing. The term " early " as applied to oats does not mean that they are sown at an earlier date in the spring, but only that they mature in less time when sown on the same date. Where the summer climatic conditions are favorable for the growth of late oats, they not only outyield early oats but the common varieties are better in color and quality.

However, early oats have an advantage in dry regions or where summer drought is apt to come.

Hulless Oats.—There is one kind of oats known as "Chinese hulless" oats, in which the kernel threshes out free from the hull. It does not yield well, but is sometimes grown as a novelty (Fig. 57).

FIG. 57.—On left, large white oats, open panicle, variety Big Four. On right, Chinese hulless oats.

Description of Oat Plant.—A typical field of early oats will average about three feet high, while late oats will usually average from six to twelve inches taller. A very large growth of oats will

sometimes average five feet. The *stem* is hollow with four to five nodes and as many leaves. Leaves ordinarily are about one-half inch in width, but there are certain robust late varieties with leaves one inch wide. As compared with wheat the oat plant bears an average of at least one more leaf per plant, and the leaves average larger in size. The stem of oats will "straighten up" well after being blown down by severe storms, if it is not too mature. This is accomplished by bending at the lower joints.

Tillering or Stooling.—The number of stems from a seed will vary with (*a*) soil conditions and (*b*) rate of planting. The tillers come from latent buds at the base of the stem. If single oat plants be planted one foot apart in a rich garden soil and given good care, from ten to fifteen buds may be stimulated to develop into as many stems. However, if the plants be crowded, as under field conditions, one plant to every one or two square inches, very few tillers develop. This is well illustrated by some data secured at the Nebraska Experiment Station where oats were sown for two years at rates varying from 4 to 16 pecks per acre. The following table shows the number of stems to 100 plants.[2]

Rate of Seeding and Tillering

Year	Rate of sowing per acre		
	4 pecks	8 pecks	14 pecks in 1907 16 pecks in 1908
1907	280	289	106
1908	466	279	139
Average	373	284	122

Here we see that for the thick planting only 22 plants in 100 had more than one stem, while in the 4-peck rate of seeding each plant had from 2 to 3 tillers.

In cold clay soils oats seldom tiller much even when sown thin. For example, in Scotland six bushels of seed are sown per acre, as the plants tiller very little even if sown thinly, due to the cold wet soil.

Description of Oat Spikelet.—The various types of oat panicle have already been described. The oat spikelet normally bears

[2] Nebraska Experiment Station Bulletin, 113, p. 10, 1910.

two flowers. They are usually self-fertilized, though natural crossing occasionally occurs. Varieties vary in respect to the development of the second flower into a grain. In some cases there is a strong tendency for only the lower grain to develop, while, on the other hand, there are varieties that show a strong tendency to develop both grains equally. A few varieties develop three grains normally. Between these are all intermediate stages. In general, the second grain is about two-thirds the size of the lower grain.

The Oat Grain.—Except in the case of "hulless" oats the oat kernel is always tightly enclosed in the flowering glume, called the hull. The kernel and hull combined are called a "grain" (Fig. 55).

The proportion of kernel in good oats will usually average about 70 per cent and hull 30 per cent. Oats are quite variable in this respect, however, the usual range being from 25 to 35 per cent hull, with occasional extreme variations as low as 20 per cent and as high as 45 per cent. A good example may be cited from the Ohio Experiment Station, where 36 varieties showed a variation in *one season* of from 23.9 per cent to 36.7 per cent hull.[3] As these data illustrate several common variations in oat varieties, a list of 10 selected varieties with accompanying data is given:

Characteristics of Ten Common Varieties of Oats

	Color	Number kernels per ounce	Per cent of		Average weight per bushel	Stiffness of straw	Number days to mature	5 year average		
			Hull	Kernel				Grain per acre, bushels	Straw per acre, pounds	Pounds straw per bushel of grain
Black Mogul....	Black .	1,233	36.7	63.3	23.5	96	112	45.5	4,225	93
Hvitling........	White .	952	23.9	76.1	28.0	82	107	60.2	3,276	54
Joanette........	Black .	1,146	24.0	76.0	29.2	84	111	66.8	3,630	54
Lincoln.........	White .	1,032	27.8	72.2	28.1	81	99	68.3	3,471	51
Seizure..........	Yellow.	1,276	30.3	69.7	26.3	91	110	60.1	3,690	61
Sixty Day......	Yellow.	1,384	25.8	74.2	27.9	80	96	68.5	2,448	36
Swedish Select..	White .	823	27.0	73.0	28.7	82	101	60.0	3,234	54
Watson.........	White .	1,416	35.5	64.5	27.0	88	109	61.6	3,610	59
Welcome.......	White .	1,523	28.1	71.9	27.0	73	104	63.2	3,803	60
Wideawake.....	White .	1,268	26.5	73.5	29.3	73	100	59.4	3,922	66

[3] Ohio Bulletin 257, 173.

Factors Affecting Percentage of Hull.—While there is a marked variation in percentage of hull, it does not seem to be closely related to any particular character of the grain. In fact, a variety high in per cent of hull one year may be low another, as noted by Warburton [4] regarding certain experiments in Wisconsin. The varieties ranged from 69.13 to 78.07 per cent in 1905, and from 63.71 to 69.86 per cent in 1907; *the variety with the lowest percentage in 1905 being highest in 1907.*

Shape of grain has several times been studied in relation to weight per bushel. While there is some evidence that the long slender type of grain is likely to have a higher percentage of hull than the short thick type, still it is by no means a constant relation.

Weight per bushel does not bear a close relation to percentage of hull within certain limits, as illustrated by the preceding table in the Watson and Welcome varieties, both weighing the same. In general, oats weighing less than 28 pounds per bushel will be high in per cent of hull, while oats weighing more than 34 pounds per bushel will be low in hull, but little relation will be found between these two limits.

Varieties vary in percentage of hull, and a long variety test covering many years will show average differences, but it will be found that a variety averaging low in hull in one region will often average high in another place.

In conclusion, the general results indicate that the variety best adapted to a certain region, and therefore matures fully in the most normal way, will ordinarily be low in percentage of hull. Those varieties not well adapted naturally do not develop a good kernel and are high in percentage of hull. This explains the reason why varieties may vary from year to year. For example, in a season favoring early varieties, these are the best developed and highest in percentage of kernel, but in a season favoring the late varieties, conditions are reversed and late oats are then best developed and higher in percentage of kernel than the early oats.

Value of Hull and Kernel.—The following table gives the comparative value, so far as an analysis will indicate, of the hull and

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[4] Farmers' Bulletin 420, 15.

kernel of oats.[5] The figures give the total number of pounds of the constituents in 100 pounds of dry matter:

Composition of Parts

	Ash	Protein	Fiber	Carbo-hydrates	Fat
Oats grain	3.3	13.3	10.7	67.1	5.6
Oats kernel	2.2	*16.0*	1.0	73.1	*7.7*
Oats hull	7.2	3.6	*32.0*	56.1	1.1

The data show the oat kernel to be very high in protein and fat, while the hull is high in fiber. Also in comparing the carbohydrates in kernel and hull, it should be noted that in the oat kernel this constituent is largely starch, and more valuable as a feed than the cellulose material of the hull, a form of carbohydrate lower in feeding value than starch. In fact, oat hulls are not much different in feeding value from oat straw.

Estimating Value of Oat Grain.—Oats are usually bought or sold by weight. If we estimate the feeding value of oats on the per cent of kernel contained, it is evident that oats containing 75 pounds of kernel to 100 pounds of oats are more valuable than those containing only 60 pounds.

Example: If oats with 25 per cent hull are worth $1.25 per hundred, how much are oats with 40 per cent hull worth, estimating the comparative value on the kernel only?

Weight per Bushel.—The legal weight of a measured bushel of oats in the United States is 32 pounds, with the exception of a few States, while in Canada it is 34 pounds.

Oats commonly vary in weight from 25 to 35 pounds per bushel. Very heavy oats will occasionally weigh 40 to 45 pounds and very light oats as low as 20 pounds. The average oat crop weighs less than 32 pounds per bushel. In the market No. 1 oats must weigh 32 pounds per bushel; No. 2 oats 28 or 29 pounds; and No. 3 oats 24 pounds. Ordinarily there is a difference in price of one to three cents per bushel in a grade. All other things being equal the heavier oats will be more valuable, but not always, as well

[5] Farmers' Bulletin 420, 16.

developed oats may sometimes have a light weight due to certain characters of the grain.

Varieties having an awn on the grain or an extended loose hull, do not settle close in the measure. In such a case well matured oats with a low per cent of hull will weigh less than 32 pounds per bushel. Oats slightly damp do not weigh as much. Oats very ripe and dry when threshed will often be "clipped" enough by the threshing machine to increase the weight per bushel. All this must be considered in estimating the value of oats when the weight is known.

Clipped Oats.—Oats are clipped in the large elevators by passing them through a "scourer" or machine that rubs off the awns, extending hull, the rachilla at the base of the grain, or any loose part. This increases the weight per bushel, according to how close the clipping may be. The legal weight of clipped oats is 36 pounds per bushel.

Quality of Oat Straw.—Oat straw contains more protein and fat than the straw of other cereals or corn fodder. It does not contain the long awns and hard chaff common in wheat and barley straw, making it more desirable as a feed. Also oat straw is usually cut much greener than other cereals, and is therefore softer and more palatable. In fact, good green oat straw, well cured, is considered a fair substitute for at least a part of the hay in feeding horses, when not at hard work.

Proportion of Grain to Straw.—In the data cited in the preceding table of varieties there is a variation as an average of five years of about one pound to three pounds of straw to one pound of grain. There is no constant relation, but, in general, medium or late varieties usually have about two pounds of straw to one pound of grain, while early varieties produce somewhat less proportion of straw. The proportion of straw to grain is comparatively high in oats, generally estimated as two to one, while one and one-half to one in wheat, and one to one in corn. Various factors increase the proportion of straw, as soils rich in nitrogen, thick planting, or unfavorable climatic conditions while the grain is ripening but after the straw is well grown.

EXERCISES

Study of Oats Types.—Oats belong to the family of *Gramineæ*, the genus *avena*, and species *sativa*.

They differ from wheat and rye mainly in having the grain borne in a panicle rather than in a spike.

Oats are classified into types largely on the basis of shape of the panicle. In this way we have three main types of oats:

1. Panicled (branches of panicle diverging broadly from central axis).
2. Compressed (branches closely adjacent to the central spike).
3. Side (branches all inclined toward one side of the central axis).

Drawing Work

1. Draw twice natural size details of a spikelet. (*a*) Show each grain, awns, and outer glumes. (*b*) Show the lower flower spread apart, labeling outer glume, hull, dorsel awn, kernel, and palea.
2. Draw spikelet of hulless oats twice natural size.
3. Draw spikelet of wild oats twice natural size.
4. Draw head of panicled oats natural size.
5. Draw head of side oats natural size.

Write a clear statement explaining wherein oats differ from wheat in (1) the head; (2) spikelet; (3) grain.

Descriptive Terms for Oats

A. Panicle:
1. Shape—spreading, side.
2. Structure—compact, medium, open.
3. Awns—straight, twisted, kneed.

B. Spikelet:
4. Color—whitish, yellowish, reddish.
5. Width—wide, narrow.
6. Number of grains—1, 2, etc.

C. Grain:
7. Color—white, yellow, red, black.
8. Shape—slender, medium, plump.
9. Crease—full, narrow.
10. Tip—refers to extension of hull.
11. Per cent hull.
12. Per cent kernel.

On the following outline describe several types of oats.

Outline for Describing Oats

Name of variety........	....	....	....	....	....
A. Panicle:					
1. Shape........	....	....	....	....	....
2. Structure.....	....	....	....	....	....
3. Awns........	....	....	....	....	....
B. Spikelet:					
4. Color........	....	....	....	....	....
5. Width........	....	....	....	....	....
6. Number grains.	....	....	....	....	....
C. Grain:					
7. Color........	....	....	....	....	....
8. Shape........	....	....	....	....	....
9. Crease........	....	....	....	....	....
10. Tip........	....	....	....	....	....
11. Per cent hull...	....	....	....	....	....
12. Per cent kernel.	....	....	....	....	....

QUESTIONS

1. State the importance of oats and other crops.
2. Name leading continent in production of oats, corn, and wheat.
3. Which are the two leading countries in production of above crops?
4. Is yield per acre increasing?
5. Why are yields so low in Russia and in the United States?
6. In the United States how does the oat region compare with the wheat and corn regions?
7. Describe principal types of oats by shape of head, color of grain.
8. What kinds are grown in your neighborhood?
9. Where are the different types grown in America?
10. Where are oats sown in the fall?
11. Where do early oats give best yields? Where late oats?
12. Give the factors affecting tillering of oats.
13. Compare corn, wheat, and oats as to cross- and self-fertilization.
14. How many grains in an oat spikelet? Corn? Wheat?
15. Give the factors affecting percentage of hull in oats.
16. Give the importance of weight per bushel.
17. What factors affect weight per bushel?
18. What is the comparative value of hull and kernel?
19. What are clipped oats?
20. What is the value of oat straw?
21. How much straw to grain in oats? Wheat?
22. What factors would you say influence per cent of hull?
23. Is weight per bushel related to per cent hull?
24. Is weight per bushel related to feeding value?

CHAPTER XXI

CULTURE OF OATS

The oat crop is grown by comparatively simple cultural methods. It is apparently less particular in the kind of soil or preparation than most crops, except buckwheat. Ordinarily, it does not respond as quickly to fertilizers or manures or thorough soil preparation as other cereals, and hence is grown by less intensive methods.

Climatic Requirements.—Oats require a rather humid climate. It requires more water to grow oats than other of the common grain crops. For example, farmers find that an oat stubble is always much drier to plow, after harvest, than a wheat or barley stubble.

Importance of Water.—By growing crops in barrels or large cans, it is possible to determine how much water is required by different crops to produce one pound of dry weight. Results of two experiments are here cited, one by King in Wisconsin and the other by Briggs and Shantz in eastern Colorado:

Water Required in Proportion to Dry Matter Produced

Crop	Pounds of water to produce one pound of dry matter	
	King's experiment in Wisconsin	Briggs and Shantz's in Colorado
Oats	541	614
Barley	388	539
Wheat	...	507
Corn	350	369

Not only must the supply of soil moisture be large but a rather cool summer, favoring slow ripening, gives best results. Wheat will do well in hotter and drier summer weather than oats.

This explains why early oats often do so well in the Corn Belt. Ripening early in July they will escape more of the hot, dry weather of midsummer than later oats. It is also one reason why oats, relative to wheat, are so much more important in northern and northeastern United States and eastern Canada, while wheat has a distinct advantage where summers are hot and dry.

Soils Adapted to Oats.—Given a favorable climate, oats do well on all productive soils. However, the oat crop requiring more water than other grain crops, most often suffers from lack of water and appears to be favored by heavy, retentive soils. In fact, many soils too wet for good corn-growing produce excellent oats. However, a poorly drained soil is not better suited for oats than for wheat or barley. Very rich soil is often not suited to oats, as oats lodge readily when the growth is rank.

Wheat and barley are usually classed as "delicate feeders," meaning that they require easily available fertility, and respond quickly to thorough preparation of the soil and fertilizers. Corn is considered less sensitive to soil conditions, and is sometimes called a "coarse feeder." While oats apparently can not utilize coarse manure so well as corn, they are considered even less sensitive to good preparation and fertilizers.

While all the cereals do well on a virgin soil it is often true that long after wheat and barley cease to give good crops without fertilizers or manure, both corn and oats can be profitably raised. In the older States where oats do well, as New York, wheat-growing is largely concentrated on the best soils, while oats are generally grown on all farm land.

In comparing the relative importance of climate and soil it appears that a favorable climate, namely, sufficient moisture with a slow ripening season, is more important than character of soil.

Fertilizer and Manure for Oats.—On general grain farms or grain and hay farms where oats are grown, fertilizers and manure are ordinarily applied to those crops in the rotation that responds most readily to fertilizing. The fertilizer is adjusted to the rotation as a whole rather than some particular crop. Since the effect of a fertilizer usually lasts more than one year and manure several years, all crops benefit.

In a typical rotation, as corn, and then wheat, followed by clover and grass for two or more years, the wheat crop is usually the first crop to which fertilizer is applied, while the manure is applied to the sod land to be broken for corn, since corn can utilize coarse manure to good advantage.

A 5-Year Rotation

1	2	3	4	5
Corn	Oats	Wheat (fertilizer)	Clover and grass	Grass (manure)

In this case no direct fertilization would be applied to the oats, but they would benefit from manure applied to corn.

On heavy cold soils farmers often find it profitable to apply some fertilizer to all cereal crops to give a good spring growth. In many regions where the oat crop is grown extensively, little or no wheat is cultivated, and the oats receive fertilizer. This is particularly true where oats are used as a nurse crop for young grass and clover, in part for the benefit of the seeding.

Kind of Fertilizer.—Fertilizer applied directly to oats apparently gives best results in northeastern United States where soils are heavy clay, and in the South on winter oats. In this region usually more potash is recommended for oats than for wheat or barley, probably due to the heavy growth of straw and tendency to lodge. For example, a complete fertilizer for wheat, commonly recommended, would contain nitrogen, phosphoric acid, and potash in ratio of 4–8–5 or 4–12–4, while for oats 4–6–6 or 4–6–9 would probably be recommended. From 100 to 400 pounds per acre are applied.

In the Corn Belt States it seems rather clear that for all crops phosphorus is the element least available in the soil. Experiments, in general, show that here phosphate alone or with only a small amount of nitrogen and potash is most profitable. Oats are here grown in rotation with corn, wheat, and grass, and very little fertilizer is applied directly to the oat crop.

Preparation of Seed-bed.—In practically all grain-growing sections it is the custom to give less preparation for oats than for either wheat, corn, or barley. In the Middle West experiment stations, with loam soils, practically as good results have been secured with oats when corn-stalk land is prepared by double disking as when plowed and thoroughly harrowed. While with wheat or corn, early, deep plowing and thorough harrowing is always recommended. In the eastern States where clay soils are common, plowing for oats has

given increased yields, as reported by the Ohio and Pennsylvania Experiment Stations. However, even on heavy soils in good tilth and well farmed, disking without plowing may give good results. For example, at the Ohio Experiment Station previous to 1899,[1] when plowing was compared with disking for oats, the yields were 52.8 and 48.7 bushels per acre, a gain of 4.1 bushels for plowing. Fifteen years later (1909–1912) when the test was repeated, land prepared by plowing and disking yielded 58.6 and 61.9, a difference of 3.3 bushels in favor of disking. The land had no doubt been much improved in physical condition meantime, indicating that on such land plowing was not needed for oats. However, the early data indicate that on heavy farm land in average condition, plowing is best, but on land in high tilth it will not be necessary. This is also supported by the practice in some places on clay land, of not plowing when oats follow potatoes, as potato land is usually in high tilth, while corn stubble would be plowed.

Preparing Seed Oats.—If an average sample of oats be examined the grains will be seen to vary in size. The small grains are the second or "twin" grains in the spikelet (p. 151). By careful hand separation it has been shown that these small grains are not as productive as the large grains.[2] However, where machines have been used to separate large seeds from the ordinary oats, very little improvement in yield has been secured. This is shown by results from both the Kansas and Nebraska Experiment Stations.

Oats, Average Yield Per Acre in Bushels

Station	Ordinary seed from thresher	Heaviest or largest seed separated by fanning mill
Kansas[3]	29.89	30.90
Nebraska[4]	58.30	58.80
Average	44.09	44.85

Treating Oats for Smut.—The loose smut of oats is common everywhere. The affected heads become a mass of black spores at about the time oats bloom. These spores are carried about by the wind, finding lodgement on the grains of sound oats. Here they

[1] Ohio Bulletin 138, 46; also 257, 266.
[2] Ohio Bulletin 257, 274.
[3] Kansas Bulletin 74, 199.
[4] Nebraska Bulletin 104.

remain until the oats are sown the following spring. When the oat grain sprouts, the smut spore also germinates and infects the young oat plant. It lives within the plant as a small thread-like parasite, stunting the plant and turning the head into a mass of black spores.

The smut is carried from one crop to another by spores attached to the grain, and can be easily prevented by some treatment that will destroy the spores but not injure the grain. Hot water, just hot enough to kill the spores but not the grain, is used,[5] also a solution of formalin. The latter is most easily applied.

Formalin Treatment.—Standard formalin is a 40 per cent solution of the gas formaldehyde in water. Be sure the solution is standard strength. Use one pound of formalin to 40 gallons of water. Spread out the oats on a floor or in a tight wagon box. Apply the formalin solution with a sprinkling pot, shoveling over the oats at the same time until all are thoroughly wet. It will require about one gallon of solution to a bushel of oats. Then pile the oats and cover with wet sacks for several hours. This is important, so the strong fumes given off by the formalin may have full effect on the smut spores. The oats are then spread out to dry.

Time of Seeding Oats.—In the United States very early sowing is important. The reason appears to be, the need of oats for rather humid and cool climatic conditions for normal development. The more advanced the growth before the high temperature and drier weather of midsummer comes, the better the quality and yield are likely to be. Early maturing oats also avoid rust to some degree.

Experiments on time of sowing have been conducted at several experiment stations. The sowings usually covered a period of six to eight weeks, the first one, as soon as soil could be worked. In the United States the results have always favored the early sowings. However, in northeastern Canada, and the northern oat-growing sections in general, where the season is short and oats mature after the midseason heat, early sowing is less important, medium sowing doing as well. But going southward, early sowing becomes more and more important.

The principle is illustrated by an experiment from the Illinois

[5] For detailed directions regarding hot water for smut, see U. S. Farmers' Bulletin 250.

Experiment Station.[6] The experiment was continued for five years, the sowings beginning in March (except one year) were continued at intervals of about one week, with the following results:

Yield of Oats in Bushels for Each Sowing

Year	First	Second	Third	Fourth	Fifth	Sixth
1888..........	*66.3*	56.5	48.8	49.4	....	....
1889..........	*48.1*	41.5	41.3	36.3	33.1	25.0
1890..........	44.1	*45.1*	36.5	30.0	28.1	19.6
1892..........	46.0	42.4	*47.7*	41.7	42.4	23.9
1893..........	*55.1*	53.2	44.2	....	....	31.5
Average.....	51.9	47.7	43.7	39.3	34.5	25.0

The highest yield was secured with the first sowing three years and with the second and third sowings in other years.

In the Gulf States much of the oat crop is fall sown, during October and November. Fall-sown oats ripen two to three weeks earlier than spring-sown, a distinct advantage. Taking selected States from south to north, the time of spring sowing is shown by the following data[7]:

Dates of Sowing Oats in Different Sections

State	Beginning	General	Ending
Alabama	Jan. 31	Feb. 20	Mar. 9
Tennessee	Feb. 22	Mar. 11	Apr. 1
Kentucky	Mar. 8	Mar. 23	Apr. 11
Ohio	Mar. 27	Apr. 9	Apr. 22
New York	Apr. 19	Apr. 30	May 18
Maine	May 2	May 13	June 1
South Dakota	Apr. 8	Apr. 18	Apr. 30

In general, spring sowing extends over a period of five weeks in the South, gradually decreasing to a period of three weeks in the Dakotas. Sowing in the first half of the period is better than the last half. While South Dakota is in the same latitude as New York

[6] Illinois Bulletin 31, 385.
[7] U. S. Department of Agriculture, Bureau of Statistics, Bulletin 85.

and Maine, sowing is much later in the latter States, owing to the later thawing out of frost in spring and heavy wet soil which must be given time to dry before plowing.

Rate of Seeding.—Numerous long-time experiments have been made to determine the best rate of seeding oats. Results practically agree on eight to ten pecks giving highest net returns. Where drilling and broadcast sowing have been compared, usually about two pecks more per acre are required when sown broadcast.

The rate of seeding is influenced by the tendency to tiller in different soils and the amount of rainfall. In dry-farming regions and under irrigation, five to six pecks are sown. The warm, dry soils favor tillering (see p. 150). The other extreme is found in Scotland where oats seldom tiller, and six bushels per acre are sown. On many cold or heavy soils three to four bushels are sown.

Method of Sowing.—In sowing seed there are two important considerations, to distribute the seed evenly and at the proper depth. This can best be accomplished by use of a grain drill. By very careful work, good, uniform stands will be secured by broadcasting, though it usually takes one or two pecks more seed per acre. When this is accomplished, the broadcast will usually yield as well as drilled. This was demonstrated at the Nebraska Station during a test for four years, where the yields were almost the same. Similar results were secured at Ohio. At Kansas, Illinois, and Iowa better results in several tests were secured by drilling, the increase usually amounting to two to six bushels per acre. Under average farm conditions, there is no doubt that drilling is the most practical method of securing a good stand.

Depth of Sowing.—Oats are sown very early in the spring when the soil is likely to be cold and, also, well supplied with moisture. There is always danger that seeds, more than one inch deep at this time of year, will rot or give poor, weak plants. In a number of experiments where oats have been planted at depths ranging from one to four inches, the one-inch depth has given best results. This is shown in the following data from the Ohio Station.[8]

[8] Ohio Bulletin 138, 51.

Influence of Depth of Sowing Oats

	Average grain, bushels	Yield per acre, straw, pounds	Weight per bushel	Straw per bushel of grain
1 inch................	56.01	2655	28.5	47.4
2 inches..............	52.45	2192	29.5	41.8
3 inches..............	48.28	1955	29.0	40.4
4 inches..............	48.28	1775	29.0	36.7

There would be some exceptions to the above. In regions of low rainfall, west of the Missouri River, where the soil is often loose and dry in the spring, there is little danger of seed rotting and it is often best to plant two to three inches deep to insure sufficient moisture.

One of the common faults in sowing oats broadcast is getting a part of the seed too shallow and a part too deep. It is important to level the land first and cover with some tool that works at a shallow, uniform depth, as a disk harrow or a narrow shovel cultivator.

Oats as a Nurse Crop.—Oats are not considered to be as desirable a crop to sow grass or clover with as wheat or barley. Oats have more foliage and leave the ground drier after harvest. However, it is the principal small grain crop in many regions, and for various reasons is used to seed with in other places.

In this case, drilling the oats is better than broadcasting, as the grass and clover will get more sunshine, especially if the drill rows are run north and south. Early varieties are preferred to late, as the foliage is not so heavy. Thin sowing is often desirable, especially on strong land—not more than six pecks per acre. When the season is dry, it will favor the seeding to cut the oats early for hay.

Sowing Oats in Mixtures.—Oats and barley are very commonly grown as a mixture, especially in eastern Canada. At the Ontario Experimental Farm extensive experiments have been made, showing that a mixture of oats and barley always yields more grain per acre than either crop sown alone. For six years, barley and oats were mixed in various proportions and sown at different rates of seeding. One bushel each of oats and barley produced the largest yield of grain. Where the oat straw is used as feed there is some objection

to mixed barley straw, owing to the long beards. Early oats should be used in order to ripen with the barley.

Oats and Canada field peas are often sown to be cut either green for soiling or cured as hay. It makes an excellent forage, equal to timothy hay. About equal amounts of oats and peas (by measure) are mixed and sown at the rate of two to three bushels per acre.

Where the oat stubble is used as fall pasture, it may be improved by sowing two to three pounds of rape with the oats. It may be sown with the oats, but preferably two or three weeks later, and harrowed in. After the oats are harvested the rape will grow until frost.

Cultivation of Oats.—Cultivation is recognized as of value to many crops, as vegetables or corn. The question has often arisen in connection with the culture of small grains. Tests have been made where oats were sown in drill rows twelve to eighteen inches apart, and cultivation given with various tools. In general, sowing in wide rows has not given increased yields except under very dry conditions. Where oats are sown in regular six- or eight-inch drill rows, increased yields have been obtained in dry years by harrowing or by using a weeder.

The oats should be allowed to become well rooted, about three weeks' growth, and may then be harrowed with very little damage to the oats. Ordinarily, two or three harrowings, about one week apart, may be given before the growth is too large. A peg-tooth harrow, set at a good slant, is used, or better, a weeder.

However, the oats should be drilled, as a large percentage of the plants are likely to be destroyed with broadcast oats. A comparison of harrowing, drilled, or broadcast oats was made at Nebraska with an average for four years as follows [9]:

Influence of Harrowing Oats

Method of sowing	Treatment	Average yield, bushels	Gain or loss from harrowing
Drilled...........	Harrowed........	63.2	
Drilled...........	Not harrowed....	57.9	5.3 bushels, gain.
Broadcast........	Harrowed........	56.9	
Broadcast........	Not harrowed....	58.8	1.9 bushels, loss.

[9] Nebraska Bulletin 113, 14.

During a period of seven years when drilled oats were cultivated, there was a loss certain seasons, the indications being that it only paid in rather dry years and when the soil was in good condition. It is doubtful if harrowing would pay on heavy soils or when the spring is wet.

Spraying for Weeds.—Wild mustard is one of the serious pests in oat fields of the Northern States. Mustard seed can be removed from seed oats by careful screening, but this is often neglected or the soil is infected. The mustard can be destroyed by spraying, a solution of iron sulfate or copper sulfate being cheapest. A twenty per cent iron sulfate solution (75 pounds to 50 gallons of water) or a three per cent copper sulfate solution (12 pounds to 50 gallons of water) is effective. About fifty gallons per acre is required for a thorough spraying. The spray should be applied before the first seed pods are formed, to be most effective. Usually, a large two-horse spraying machine, such as used for potatoes, is used on large fields.

QUESTIONS

1. Where in America would you expect to find the best oat climate?
2. Where would you expect early oats to have an advantage? Where late oats?
3. Compare corn, oats, wheat, and barley in their response to fertilizers. As to soil requirements.
4. Compare the use of fertilizer or manure directly on the oat and wheat crops.
5. Give the composition of a common oat fertilizer.
6. Explain different methods of preparing seed-bed for oats.
7. Why is plowing more important on some soils than on others?
8. Are small or weak plants eliminated in nature? (See p. 17.)
9. Describe oat smut.
10. How would you determine the per cent of smut in a field?
11. Describe the treatment of seed oats for smut.
12. Give apparent reasons for early sowing of oats.
13. Where are oats fall sown?
14. Give the variation in rate of seeding.
15. Why will drilling oats give better results under average conditions?
16. What is proper depth of sowing?
17. Discuss oats as a nurse crop.
18. Name common mixtures in which oats are sown.
19. Give advantages claimed for mixtures.
20. Has it been found profitable to cultivate oats while the crop is grown, as we do corn or potatoes?
21. Tell how to destroy mustard by spraying.

CHAPTER XXII

HARVESTING AND UTILIZING THE OAT CROP

A VERY high percentage of the oat crop that would grade No. 1 or No. 2 oats when it reaches maturity, is damaged one to three grades by careless harvesting methods and handling before it reaches market. In fact, practically all damage comes after harvest, and principally either in the shock or stack (Fig. 58).

Time of Cutting.—The wheat crop usually continues to gain in weight up to the time it is dead ripe, but oats seem to give maximum yield when cut in the dough stage. With fully ripe oats there is often some actual loss, due to shattering. Also, oats cut slightly green usually have a better color, being lighter with a slightly green tinge. The half green straw is more palatable as feed, an important item on many farms.

The above advantages are partly offset by the slower curing of the greener straw and consequent increased danger from damage while in shock or stack.

Methods of Harvesting.—Oats are usually cut with a self binder. Perhaps the best grade of oats is secured by the old method before binders were used. The oats could be cut rather green and left in loose gavels for a few hours before binding. This would be impracticable nowadays. The bundles should be rather small and bound low enough to leave the head part loose.

Oats are sometimes cut with the header or combined harvester in the Far West, but the custom is not nearly so common as with wheat.

Shocking Oats.—In good curing weather, bound oats may be set at once into compact round shocks with one or two cap sheaves. In damp weather, part green oats must be handled with skill to secure grain and straw free from must or mold. The bundles may be set up at once in long shocks, two by two. A day later the bundles can be reset into a compact round shock, and capped with two bundles (Fig. 59). Sometimes it is advisable to allow green oats to lie on the ground one day and then set into round shocks, though the shock will never "set" so well when straw is half cured.

Fig. 58.—Oats harvest in Nebraska.

The secret of securing fine, sweet oats, of good color, is proper curing in the shock.

Threshing Oats.—When a threshing machine is available, just as soon as the oats are cured, it is practicable and cheaper to thresh from the shock. Investigations in Minnesota have shown a cost of about four cents a bushel to thresh from the shock, and about five cents to stack and thresh. If oats can not be threshed at once from the shock, they are then in danger of injury from rain. A heavy storm or two may easily damage oats enough to lower them one or two market grades. This means a loss of three to four cents per

Fig. 59.—Good shocks of oats, well capped.

bushel. When used for home feeding, the loss may be even greater if the straw is also valued.

Storing Oats in Barns or Stacks.—On the eastern farms there is usually barn room enough to store the oats in straw, but this is not the case in other places. Stacking is an art acquired only by long experience, and only a few principles can be mentioned. A good stack must be built very compact in the center, so that in settling the outer layers settle more than the center, thus giving a downward slant to the straw. To accomplish this the stack is kept high in the center, especially above the bulge. One danger in a high center is that the stack will spread as it settles. To prevent this, the cone

of the stack must be carried upward in rather straight lines, somewhat independent of the outer tier or two, which are kept loose. The center of the stack should be well bound in by careful overlapping, and well tied across the center. Sometimes a long stake (six to eight feet) or two is driven in the center, to better bind the center bundles.

DISEASES AND INSECTS AFFECTING OATS

Oat Smut and Rust.—The nature and control of oat smut have been described (Chapter XIX). While smut does enormous damage to the oat crop, its injury is probably small compared with the damage inflicted by rust. There is no effective method of combating rust. There are two forms, known as the crown or red rust, and stem rust. The rusts usually appear in early summer, or about the latter part of June. If the weather is humid and warm they spread very rapidly. Heavy dew and a thick, heavy growth of foliage, that prevents drying, favors the spread of rust.

Ordinarily, early sown oats and early varieties are least injured, as the leaf and stem tissues may become tough and well matured before the rust becomes general. Certain varieties show considerable rust resistance, as the so-called red rust-proof varieties of the South, although when these varieties are sown as winter oats, their early maturity avoids much damage from rust.

Spikelet blight is very common in some seasons. The lower spikelets, sometimes one-half of the head, turn white and are barren. The cause is not understood nor is a remedy known.

Blade blight occurs usually early in the season, and is characterized by a yellowing and final dying of the leaves. It is supposed to be a bacterial disease, and no remedy is known. It should not be confused with the yellowing due to poor nutrition, which often takes place on wet land or soil in poor physical condition.

UTILIZING THE OAT CROP

Most of the oat crop is utilized as stock feed, especially for horses. It has no important use in the arts. A small amount is manufactured into oatmeal. The only commercial by-product is the oat hulls, from oatmeal mills.

Data are collected each year and reported in the Yearbook of the

United States Department of Agriculture, regarding the amount of oats shipped out of the county where grown. For the ten years, 1900–1909, this amounted to 28.7 per cent of the crop or an annual movement of 246,000,000 bushels. The percentage varied from 19.5 per cent to 32.7 per cent. Most of this goes to other parts of the country for stock feed; the principal movement being from the six states, Illinois, Iowa, Wisconsin, Minnesota, Nebraska, and Indiana, to the eastern and southern States.

Preparing for Market.—Farmers ordinarily market oats as they come from the threshing machine, but in the large terminal elevators, where they accumulate, a large percentage of the commercial oats are given some treatment to prepare them for final shipment. The legal weight of No. 1 oats is 32 pounds per bushel, but the bulk of commercial oats will fall below this standard. In the large elevators, they are often cleaned and scoured some, which will raise the weight and improve the appearance. Very large quantities are also bleached with sulfur fumes, to improve the color. Large bleaching towers will handle several thousand bushels per day, at a relatively small cost.

A drying tower is also in connection with the large elevators, where hot, dry air may be passed through the grain, reducing the percentage of moisture to any desired degree. Oats sometimes reach the market with eighteen or twenty per cent moisture, but if they are to be stored or shipped, especially by water, the moisture should be reduced to twelve or fourteen per cent. Otherwise there is great danger of loss by heating and molding.

Market Grades.—For convenience in marketing, oats are graded at the large terminal markets by official inspectors. The oats are bought and sold very largely on these grades. There are six principal market classes, as follows:

White Oats, Grades 1, 2, 3, and 4.
Mixed Oats, Grades 1, 2, 3, and 4.
Red or Rust-proof Oats, Grades 1, 2, 3, and 4.
White Clipped Oats, Grades 1, 2, 3, and 4.
Mixed Clipped Oats, Grades 1, 2, 3, and 4.
Purified Oats, oats chemically treated.

For more detailed description of the grades, see appendix.

EXERCISES

OAT JUDGING

Oats are judged on the basis of their value for feed, since this is the principal use.

Thoroughly review the matter in Chapter XX of text.

Materials.—Threshed samples of oats representing large white and black oats, red oats, and early oats; also miscellaneous local samples, and one set of official grades.

Sampling.—First mix grain thoroughly and dip out about a heaping teaspoonful.

Method of Analysis.—First analyze the samples, filling out the following blank, then score samples from this data.

Report Card on Threshed Oats

(Express data in per cent)

Name of sample					
Color					
Size:					
Large					
Small					
Weight per bushel					
Soundness and purity:					
Damaged grain					
Foreign matter					
Size of grain					
Must, smut, etc					
Per cent of hull					

Score Card for Oats

Uniformity, 20 per cent:											
(*a*) In color ... 10											
(*b*) In size ... 10											
Quality, 80 per cent:											
(*a*) Weight per bushel ... 25											
(*b*) Soundness and dirt ... 10											
(*c*) Per cent of hull ... 25											
(*d*) Size of grain ... 10											
(*e*) Must, smut ... 10											
Total ... 100											

Student's name.............................. Date..................

Explanation of Score Card.—In this score card oats are judged entirely from the feeder's standpoint. It is not possible to make a score card by which an oat could be judged at the same time from the feeder's and the miller's standpoint, and also judge the grain for seed. Different points would be used in each case, and different values given them.

Uniformity in Color.—Uniformity in color and size is of only minor importance to the feeder. Divide the sample according to the color of the grains. Let the class having the largest number determine the color. Cut one point for each two per cent of other colors.

Uniformity in Size.—Divide the sample into two parts according to size of grain. Estimate per cent of small grains by count. Cut one point for each four per cent of small grains.

Weight per Bushel.—The weight per bushel is a very important consideration in estimating the value of an oat for feeding purposes. A heavy weight indicates that the grain was well matured and filled out. In the same variety a heavy oat usually has a less per cent of hull, and, consequently, a higher feeding value than a light oat. The best oats should weigh 38 pounds per bushel. Cut one point for every pound light down to 32 pounds per bushel, and two points for every pound light below this.

Soundness and Dirt.—Sprouted and decayed grains have little more value than so much trash, and may be regarded as such for judging purposes. Separate all unsound grains and dirt, estimate the per cent by weight, and cut two points for each one per cent. This cut is not limited to ten points, but may be indefinite.

Size of Grain.—Size varies greatly with varieties, but 100 grains should weigh 3 grams in heavy oats. Cut one point for every two-tenths of a gram less.

Must and Smut.—If must and smut are very apparent, the sample should be cut 10 points.

Per Cent of Hull.—The percentage of hull varies with varieties, the locality in which the oat is grown, and also depends on how well and perfectly the grain was matured. In growth the hull and bran develop first, and the starch is deposited last. However, if from any cause, such as dry weather, poor soil, injury from insects, etc., the grain is prevented from maturing perfectly, the development of the starch is somewhat curtailed, and, consequently, the percentage of hull is higher. A good oat may have as high as 30 per cent hull. Cut two points for every per cent of hull above this.

Make a statement at end of exercise as to 3 most important factors to be considered in buying oats for feeding; also indicate the best samples for feeding purposes.

QUESTIONS

1. Why are oats harvested greener than wheat?
2. What do you think the best way to care for oats before threshing?
3. What are advantages of stacking?
4. What conditions favor the spread of rust?
5. How is the oat crop utilized?
6. Where is the surplus oat crop produced?
7. Explain treatment of oats in elevators to improve market value.
8. State the principal market grades.

CHAPTER XXIII

BARLEY

Barley is the fourth cereal in importance in the United States, but sixth in the world's crop of cereals (Chapter I). In the United States it is exceeded by corn, wheat, and oats, and in the world both rye and rice surpass it in production. Europe alone produces about three-fourths of the world crop.

The Production of Barley.—The average barley crop of the world for the five-year period, 1906–1910, is shown in the following table.

Production of Barley by Continents

Continent	Bushels
Europe	959,285,600
North America	221,680,800
Asia	99,352,200
Africa	54,835,200
Australasia	3,727,800
World crop	1,338,881,600

The principal barley-producing countries (Fig. 60), together with the average yield per acre, are shown in the next table:

Average Yields of Barley by Countries

Country	Average yield per annum 1906-1910, bushels	Average yield per acre 1890-1899, bushels	Average yield per acre 1900-1909, bushels
Russia	385,880,200	13.3	14.3
United States	166,356,000	23.4	25.8
Germany	147,594,400	29.4	35.3
Austria-Hungary	143,118,000	21.1	26.3
Japan	87,413,200		

Russia and the United States lead in barley production, as they also do in wheat and oat production. The average yield per acre is low in Russia, which is also true of her wheat and oat crop, but the acreage is very large. It will also be noted that the average yield per acre is increasing in the principal countries.

Barley in the United States.—In the United States, barley culture is more concentrated in a few States than any other grain. The five leading States produce about three-fourths of the crop. It takes

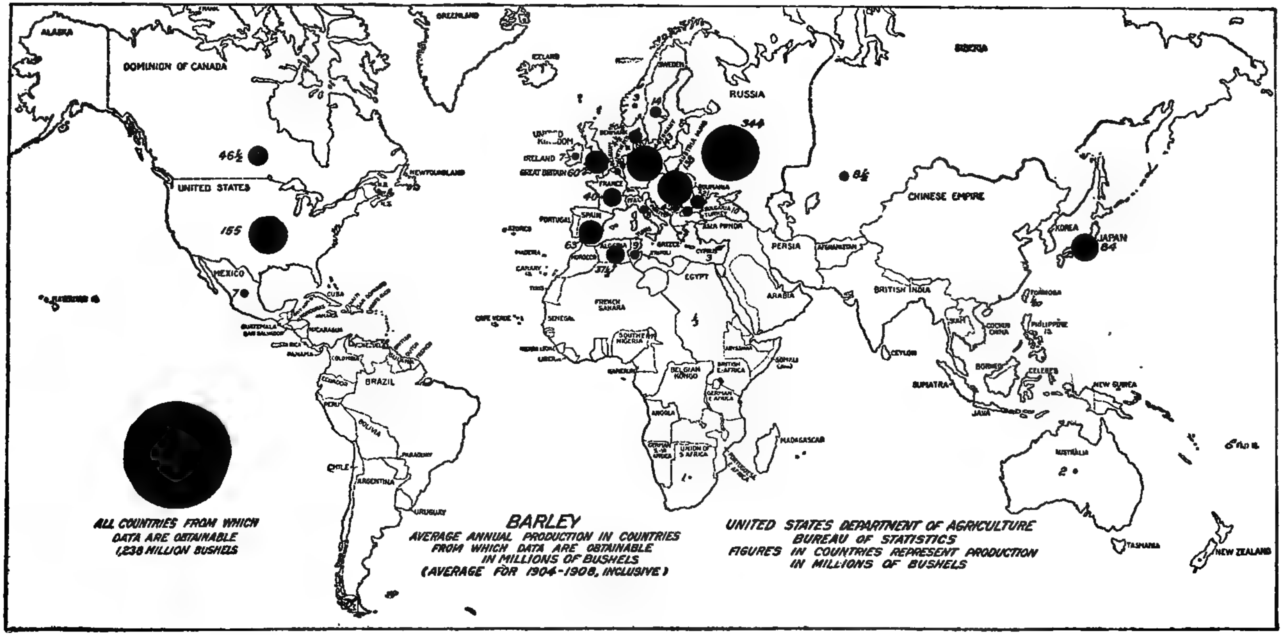


Fig. 60.—Distribution of barley production in the world. (U. S. Bureau of Statistics.)

twelve States to have as high a percentage of the oat crops, and fourteen States for the wheat and corn crops. Following is the average yield for five years, 1906–1910, in the principal States:

Yields of Barley by States

State	Bushels
California	33,782,600
Minnesota	29,867,800
South Dakota	21,238,400
Wisconsin	19,768,200
North Dakota	15,189,200

Barley in common with other cereals has shown a remarkable shift from the eastern to the western States (Fig. 61). For example, in 1850 New York State was the leading barley State, producing at that time 70 per cent of all the barley; in 1870 it produced 25 per cent; and in 1900 only 2.5 per cent.

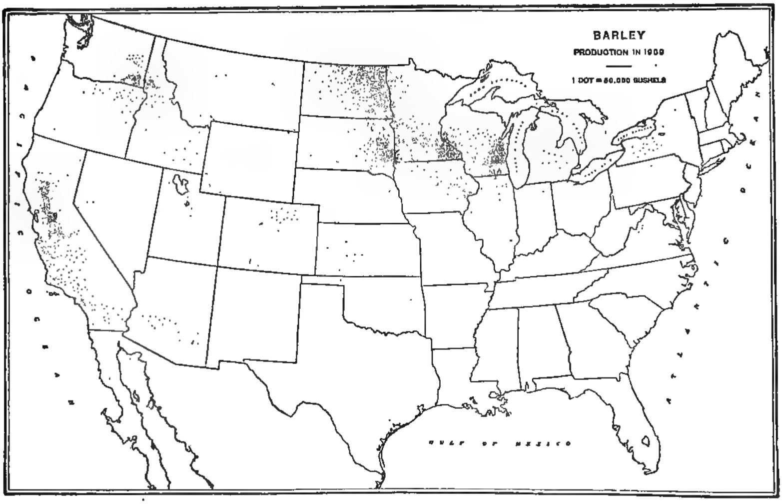


FIG. 61.—Distribution of barley production in United States. (From U. S. Census of 1910.)

As barley is grown principally for stock feed or market, it comes in more direct competition with the corn crop than any other cereal. It can not compete as a crop with corn in the corn belt, so we find it principally in the grain-growing States just out of the corn belt. In California, barley has been an important grain crop from the first, as little or no corn can be produced in that State.

FIG. 62.—The upper photograph shows heads of six-row, four-row, and two-row barley. The lower diagram in cross-section shows the position of spikelets in each type. Note that in the four-row barley the lateral rows overlap, while in the two-row they are sterile.

ORIGIN AND DESCRIPTION OF BARLEY TYPES

Origin.—In the early history of man barley was a very important human food, and probably at one time was more important as a bread plant than wheat. It probably had its origin somewhere in western Asia. During the last three centuries it has declined as a human food and is now used mostly as stock feed, and in the manufacture of beer. Its use for the latter purpose is not new, as the ancient Egyptians made it into beer.

Fig. 63.—Difference between *zeocriton* type on left and *distichum* type, both six-row and two-row, on right. The *zeocriton* is distinguished by short joints in rachis, and longer grains.

Classification of Barleys.—The most common classification of barleys is based on the number of rows of grain on the head and their arrangement (Figs. 62 and 63). There are four main groups as follows:

1. Six-row Barley (*Hordeum hexastichon*).
2. Common Six-row, lateral grains overlapping, sometimes called four row (*Hordeum vulgare*).
3. Two-row Barley, slender heads (*Hordeum distichum*).
4. Two-row Barley, broad heads (*Hordeum zeocriton*).

Structure of the Spike.—In the typical barley spike there is a certain similarity. The typical barley spikelet has but one seed with two narrow empty glumes at the base. In the six-row barleys three grains are attached together at the base. Sets of three grains being on opposite sides of the rachis, gives a total of six grains around the spike.

In two-rowed barley, only the central grain of the three is developed, the two lateral being sterile or only staminate.

In the true six-row barley the grains are spaced equal distances apart, making six distinct rows of grain (Fig. 62). In the other six-rowed type there are two distinct rows of single grains and two irregular rows, giving a somewhat four-rowed appearance, and this is

sometimes called four-row barley, but examination will show that the two irregular rows are made up of the overlapping lateral rows from opposite sides. Figure 64 gives a comparison of two types of barley grains.

The Hulless Barleys.—In ordinary barley the outer husk is tightly attached to the kernel, but there are forms belonging to all

Fig. 64.

Fig. 65.

Fig. 64.—Comparison of two-row and six-row barley grains. Upper figures two-row barley grains and lower figures six-row barley grains. Note that the two-row grains are larger and the crease is straight, while in the six-row the two lateral grains are twisted.
Fig. 65.—Kernels of hulless barley.

the four main groups in which the kernels are free from the hull (Fig. 65).

Types of Awn.—Most of the cultivated barleys have a long stout awn, but there are at least four variations:

1. Ordinary long stout awns.
2. Awns deciduous, *i.e.,* drop off as the grain ripens.
3. Awnless or awn pointed.
4. Hooded or trifurcate tips (Fig. 66).

These various types are found in all the barley groups or classes.

Color of Grain.—Ordinary cultivated barleys have a whitish grain, but in some the husk may be black or bluish. In others the grain is either white, green, purple, or black. There seems to be no important significance attached to color, except the trade prefers the white barleys.

Winter and Spring Barleys.—There are no winter barleys that can withstand the severe winter conditions of winter wheat or winter

FIG. 66.—On left, the hooded or trifurcate type, and awned barley on right.

rye. Neither do they have a long, fixed, dormant period as winter wheat and rye, but in most cases may be sown in early spring as well as fall. There are quite a number of varieties of six-row barley, of both the true six-row and the common six-row, sufficiently hardy to be sown in the fall in mild climates. Winter barleys are grown about as far north as Tennessee, but north of the Ohio River they usually winter-kill and are too uncertain for general culture.

Types in Cultivation.—In considering the value of the types, neither the true six-row (No. 1) nor the broad two-row (No. 4) is

cultivated extensively. They both yield well, have a very stiff and short straw, but the grain is coarse and not considered good malting barley.

The bulk of the crop is made up of common six-row (No. 2) or the long slender head type of two-row (No. 3), and ordinarily when two-row and six-row barleys are spoken of these are the ones referred to.

Distribution of Types.—In general, common six-row barley is adapted better to a warmer climate and lower elevation than the two-row, while at higher elevations and more northern climate the two-row is equal or superior. Hence, we find six-row grown through the corn belt and the Wisconsin-Minnesota territory. But in the high elevations of Montana and northern climate of Canada much two-row is grown. In the Dakotas both types are grown, but the two-row is mostly in the western half at high elevation.

The white and black hulless barleys have also found a place in the northern portion of the dry plains lying east of the Rocky Mountains. They mature in a short season and produce grain on a low rainfall, if the climate is not too hot.

Varieties in Use.—A large proportion of the barley grown in this country is known as "common" six-row barley, the origin of which is not known, but appears to be barley principally grown in this country for fifty or sixty years. It probably originated from several sources, and is more or less mixed. Most of the named varieties are of more recent introduction and may be briefly described as follows (Fig. 67):

Six-row Barleys.—*Manchuria,* said to be originally from China, but brought to Wisconsin from Germany.

Oderbrucker, introduced by the Ontario Agricultural College from Germany. This variety and Manchuria are similar and are the best barleys for the district, Minnesota and eastward and south to the Ohio River.

Scotch is also a six-row barley introduced somewhat earlier and extensively grown, but is now superseded by the above varieties.

Bay Brewing is an important California variety that has long had a good reputation for fine quality.

Hulless Six-row.—The hulless varieties in cultivation are all six-row, although there are two-row sorts.

FIG. 67.—Types of six-row barley. Left to right, (1) Manchuria, (2) black hulless, awned and (3) awnless white hulless.

Black Hulless, with purple to black seeds.

Guy Mayle, or Himalaya, with blue to green seeds.

White Hulless (*Success* is a variety), with light amber seeds.

Two-row Barleys (Fig. 68).—*Chevalier,* best known of two-row barleys, with long slender drooping heads.

Fig. 68.—Types of two-row barleys. Left to right, bearded *distichum* type, and deciduous *distichum* type. On right is *zeocriton* type.

Hanna, a similar but somewhat earlier variety.

Hannchen, similar to above.

Swan Neck, similar to above.

Comparative Quality.—Barley grains (Fig. 69) are classed as "mealy" and "hard," very much as the soft and hard wheats. As in wheat, the mealy grains are low in protein, having ordinarily eight to ten per cent, while the hard grains may run twelve to fourteen per cent. In Europe the brewers want the mealy barleys and give a higher price for them, but in America there is little preference on the market.

In general the two-rowed barleys are larger in grain and softer than six-rowed (Fig. 70), and are grown in preference in the barley

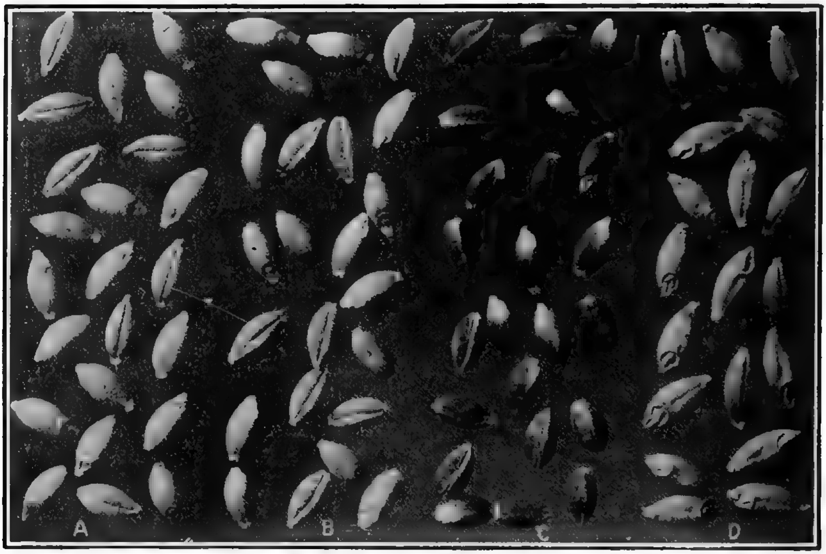


FIG. 69.—Four types of hulless barley kernels.

regions of Europe, where barley is grown principally for malting. In America it is largely a question of yield that determines the type grown.

Quality in Barley.—Quality in barley must be judged largely by its adaptation to malting, as good malting barley usually sells from ten to fifteen cents per bushel higher than feed barley. Malting is judged largely by the following three factors:

1. *Germination.*—In the manufacture of malt the barley is first germinated by keeping moist in a warm room. The barley grains

should all germinate quickly and uniformly—at least 95 per cent germination in 72 hours.

To secure this quality the barley should: (1) ripen uniformly in all parts of the field, as green and ripe harvested barley will not germinate alike; (2) the barley should be well ripened; (3) should be well protected from weather after harvest, as continued dampness, in a wet bundle, for even one or two days, will start germinating process. If a part of the grain be exposed, as the cap sheaves for

Fig. 70.—Comparison of spikelets of six-row (three at a node) and two-row (one at a node, and two sterile) barleys.

example, and the rest be well protected, the grain will no longer be uniform in quality.

2. *Color* is an indication of germinating quality. A natural bright straw color is desired, but if any considerable percentage of grains are blackened or darkened, it indicates exposure in the field. Overheating in the stack is indicated by a dark-brown color at the germ end, due probably to oil coming from the germ.

3. *Per Cent of Hull.*—In barleys the per cent of hull varies from eight to twenty per cent, with twelve or fifteen per cent as an average.

In malting the hulled barleys are preferred to hulless, as the hull protects against fungus while malting and also serves as a filter when extracting. The hull, however, is dead loss, as it is mostly fiber, and therefore a low per cent is desirable.

If the barley is plump a thin hull is indicated, by being wrinkled across the back and also by absence of the two strong veins, while in a thick coarse hull the two veins are quite prominent.

4. *Close Threshing.*—In good barley the awn should not be broken so close that the end of the kernel is exposed, but on a good percentage of grains a stub of awn one-fourth inch long is regarded as desirable. This can be regulated by adjustment of the threshing machine, and should be given attention when barley is being threshed for market.

Feed Barley.—The term "feed barley" is given on the market to barley that for any reason is not suitable for malting. In some cases only the germinating quality is injured, and the grain is of good weight, but usually feed barley is rather light in weight, broken and chaffy.

EXERCISES

Barley differs from wheat and rye in having three flowers at a joint of the rachis, and but one grain per spikelet.

In the six-row barleys all three flowers are fertile and bear grains.

In the two-row barleys the lateral flowers are sterile.

It will be observed that the empty glumes are very narrow in barley, while in wheat and oats they are broad, enclosing the flower.

Read carefully text on classification of barleys.

Barley Types.—1. *Materials.*—Have at hand samples of the four principal barley types, as described in Chapter XXIII, and, in addition, hulless barleys of both the awnless and hooded types.

2. Lay out heads of the types in order.

Lay brace of spikelets from each type just below the respective type.

3. Compare *hexastichon* and *vulgare.*

Are all three grains in a brace same size?

Are any of the grains twisted?

Compare the shape of grain, and also the prominence of the two nerves on back.

Can you identify threshed samples of the two kinds?

4. See if you can find marks for identifying the two-rowed types in threshed grain.

Can you tell the threshed grain of the two-rowed and six-rowed apart?

5. *Drawings.*—Make drawings (x3) as follows:

(*a*) Spikelet of each type on short section of rachis.

(*b*) Side view (groove side) of short section of each spike.

(*c*) Ventral view (crease side) of one grain of two-rowed barley, and three grains from same brace of common six-row (*vulgare*).

6. Dissect a spikelet of hulless and draw parts in relative position.

7. Threshed grain of white hulless barley and macaroni wheat are sometimes confused. Compare samples.

8. Compare threshed oats and common barley.

Can you remove hull as easily in one case as the other?

Which has higher per cent of hull?

Descriptive Terms for Barley

A. Spike:
1. Rows—six, two.
2. Type—slender, compact.
3. Cross-section—6 rank, 4 rank, 2 rank.
4. Awns—awns persistent, awns deciduous, awnless, hooded.

B. Spikelet:
5. Number fertile.
6. Number sterile.
7. Color.

C. Grain:
8. Glumes—free, adhering.
9. Color of kernel.
10. Shape— long, medium, short.
11. Texture—starchy, dull, vitreous.

Outline for Describing Barleys

Name of sample ....

A. Spike:
1. Rows ....
2. Type ....
3. Cross-section ....
4. Awns ....

B. Spikelet:
5. Fertile ....
6. Sterile ....
7. Color ....

C. Grains:
8. Glumes ....
9. Color of kernel..
10. Shape ....
11. Texture ....

Examining the Quality of Threshed Barleys.—Good malting barley is judged by three principal characters: (1) It should be of a uniform bright color. (2) Should be of a uniform texture. (3) Should be fairly plump and well matured. The reasons are explained in the text.

For making a comparative examination of a number of barley samples, the following outline may be used:

Report on Barley Samples

Name of sample	....
Color:	
Bright	....
Discolored	....
Texture:	
Starchy	....
Dull	....
Vitreous	....
Maturity:	
Large, plump	....
Medium	....
Shrunken	....

QUESTIONS

1. How important is the barley crop?
2. Do the same countries that lead in barley production also lead in other cereals?
3. Which countries lead in yield per acre of barley? Of other cereals?
4. How does the barley-growing region in the United States compare with the region for other cereals?
5. Name the principal types of barley.
6. Describe the difference between a six-row, four-row, and two-row barley.
7. Describe (1) hulled and hulless barleys; (2) kinds of awns; (3) color of grain.
8. How does the range of winter barleys compare with that of winter wheat; winter oats; winter rye?
9. What types of barley are commonly cultivated?
10. Give the distribution of six-row, two-row, and hulless barleys.
11. What is the difference in appearance of grain in two-row and six-row barleys?
12. Name the qualities of a good malting barley.
13. Compare per cent of hull in barley and oats.
14. How is thick hull told by appearance?

CHAPTER XXIV

RYE

RYE is the fifth cereal in importance in the world and in the United States. It is exceeded in the world by corn, wheat, oats, and rice, and in the United States the rice is replaced by barley. Rye is cultivated in much the same way as wheat and is used for similar purposes, and in many places may be considered to be a competing crop with wheat. It will grow on poorer soils than wheat and in colder climates, and so has a distinct advantage in many countries.

Rye Production.—About nine-tenths of the rye crop is produced in Europe (Fig. 71). Rye is only a minor crop in other parts of the world.

Production of Rye

Continent	Production, 5-year average, 1906–1910, bushels
Europe	1,536,279,600
North America	40,162,400
Asia	25,809,600
Australasia	189,600
Total	1,602,441,200

While the rye crop of the world is only one-third that of wheat, yet in Europe the two crops are almost of equal importance, and in at least two countries, Russia and Germany, rye far outranks wheat.

Production of Rye and Wheat in Russia and Germany, Average 1906–1910

	Rye, bushels	Wheat, bushels
Russia	742,482,600	557,757,800
Germany	409,271,800	138,184,600

In the United States, four States, Pennsylvania, Michigan, Wisconsin, and New York, produce about three-fifths of the rye crop.

Origin and History.—While the cultivated species of rye are annuals, it is thought to have originated from a wild perennial form found growing in South Europe to Central Asia.

The fact that pasturing off rye closely for a season may cause it to live over a second winter, shows it to have a tendency toward a perennial form. No other cereals appear to show such a tendency.

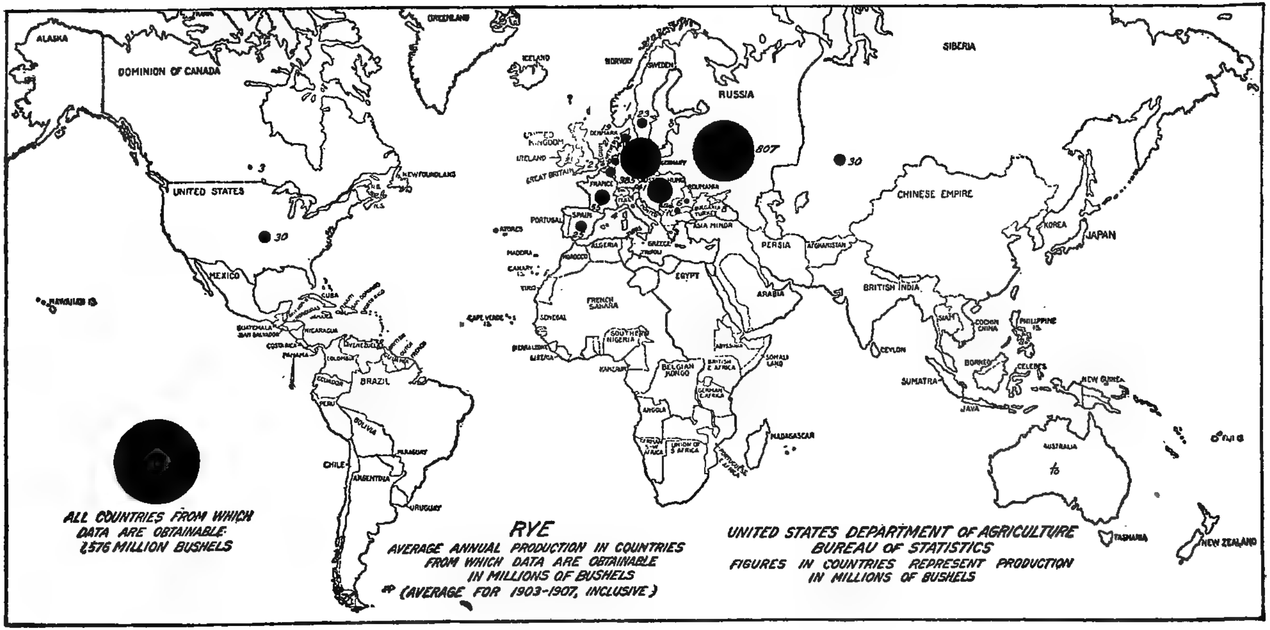


FIG. 71.—Distribution of rye culture in the world.

Rye was probably not cultivated by ancient peoples previous to the Christian era, as wheat and barley were. It appears to have come into cultivation in the north half of Europe, somewhat previous to the Christian era, and its culture since then has remained in that region.

Description of the Plant.—The rye plant is similar in general appearance to wheat, but will average ten to fifteen inches taller. The head (Fig. 72) is longer and more slender, with generally two flowers to a spikelet, giving a quite uniform four-ranked head instead of six-ranked. Rye appears to be quite generally cross fertilized instead of self-fertilized as wheat and barley. Rye straw is much tougher and more flexible than other straws, thus adapting itself to many uses in the arts, such as packing or weaving into matting.

Fig. 72.—Rye.

The Rye Grain.—The structure and composition of the rye grain is similar to wheat, although the flour made from rye is more starchy than from wheat. The rye grain contains gluten, and is therefore adapted to the making of light bread, a quality also of wheat but not found in any other cereal.

Classification of Rye.—The varieties of rye are very few compared with other cultivated cereals. The heads are practically all of one type, though the color of grain varies somewhat. Ryes are often designated as black, white, or yellow, according to color of grain. No rye has black grains, but rather dark brown or purplish, and makes a dark flour, the bread

from which is often called *black* bread in contrast with the *white* bread of wheat. So-called white rye is only lighter, but does not make so white a bread as wheat.

There are several varieties of winter rye (sown in the fall) and corresponding varieties of spring rye. Spring rye is grown some in Europe, but only rarely in the United States.

Climate for Rye.—Winter rye is much hardier than wheat, and can be cultivated in regions having colder winters or drier and more unfavorable winter weather. While it will grow throughout the temperate zone, it seems naturally adapted to northern climates.

Soils for Rye.—While it responds to good soils, yet rye is such a vigorous plant that it will produce a crop on poorer soils, or with less preparation of the soil than other cereals. It is also well adapted to light or sandy soils, and on such soils is often grown to plow under as a green manure crop.

Rye in Rotations.—Owing to its adaptation to poor or sandy soils, rye becomes a very important crop in the building up of such soils. If sown in the fall, it makes a quick growth the following spring and may be plowed under in May in time to plant some other crop, as corn, potatoes, or buckwheat. It is used in this way on the sandy potato and truck soils of the Atlantic Coast. A crop of potatoes or buckwheat can be harvested each year and a crop of rye can be plowed under for manure.

When rye follows corn it is often sown in the standing corn at the last cultivation, or is drilled in later with a narrow drill. When rye follows potatoes it may be sown while the potatoes are being dug, and the soil leveled afterward, or the land is prepared after digging and the rye is drilled in. The winter rye prevents erosion, and also prevents the leaching of any soluble fertilizer or plant-food in the soil.

When rye and buckwheat are alternated, the rye may be sown with the buckwheat about July first, sowing the buckwheat rather thin (two or three pecks per acre). The buckwheat is harvested for grain, while the young rye is allowed to grow and is plowed down the following summer. This may be repeated year after year, gradually improving the soil by the large addition of organic matter.

Rye and Vetch.—Winter or hairy vetch is often grown with rye. The vetch is a legume, adding nitrogen to the soil, and is well adapted to sandy land. The mixture may be plowed under as a green manure or, if allowed to ripen, harvested together. After threshing, the rye and vetch seeds are separated by machines especially adapted for this purpose. This is also a good way of growing vetch for seed.

Cultural Methods.—While rye responds to good preparation, as other crops, yet it is so hardy and vigorous that a stand and crop may be secured under quite unfavorable conditions.

The rate of sowing varies from one to three bushels per acre: the less amount when conditions are favorable and long coarse straw is desired, but more seed is used with less favorable conditions and when the rye is to be used as a green manure crop.

The time of sowing rye may extend over a period of three months. About September fifteenth would be most favorable in the corn belt, but it may be sown early in August and pastured off, if the growth is too rank. Rye is often sown in July in standing corn at the last cultivation, in which case it makes only a light growth until the corn is ripe or harvested. In some cases rye is purposely sown so late that it will only barely sprout before freezing weather, in which case it should be sown rather thickly.

Harvesting Rye.—When rye is grown for grain it is allowed to become quite ripe, but, in some regions, rye is grown quite as much for the straw as for the grain. When the rye straw is to be used in the padding of horse collars or for the manufacture of matting, it is usually cut while quite green, bound in small bundles and carefully cured. As soon as dry in the shock the bundles should be stacked in the barn, or under a shed, where it will go through the "sweat" or natural heating process. This leaves the straw with a good color and tougher.

Threshing Rye.—When the straw is to be sold it is usually kept straight. To do this, only the heads are thrust into the threshing machine, and the bundle withdrawn and thrown aside. There are also special machines for threshing rye, in which the bundle is fed in sideways, but only the heads are threshed, the straw passing

through the machine sideways and bound again in bundles at the rear end.

Market for Rye Straw.—In the large cities there is a large demand for straight rye straw. Its most extensive use is in the livery stables to be used as bedding. The tough nature of the straw permits it to be dried and used several times. In the New York market straight rye straw is usually quoted about as high as No. 2 timothy hay. For illustration, the following are New York quotations at different times:

Rye Straw Compared with Timothy

	Jan. 11, 1913 Dollars	Dec. 6, 1913 Dollars
Timothy No. 1	21.00 @ 22.00	20.50 @ 21.50
Timothy No. 2 ...	17.00 @ 19.00	18.00 @ 19.00
Timothy No. 3 ...	15.00 @ 16.00	15.00 @ 17.00
Rye straw	18.50 @ 18.50	15.00 @ 18.00

The price of rye straw is one reason why a large acreage of rye is raised in New York State and Pennsylvania, as the straw is worth about as much as the grain, making it a comparatively profitable grain crop.

Rye straw is also used wherever a coarse straw packing is needed and in upholstering. Coarse matting is also made, but where rye straw is used in the making of fine matting, as straw hats, the straw is especially grown, cut very green, cured with great care, and bleached.

World's Rye Crop and Price of Wheat.—While the rye crop in the United States is small, yet the price of American wheat is considerably influenced by the world's rye crop. As mentioned heretofore, rye is almost as important as wheat in Europe as a bread crop. As Europe is our principal market for wheat, a large European rye crop will cut down the demand for our wheat. In estimating the probable European demand for wheat, the rye crop is always counted in with the wheat.

Insect Enemies and Diseases.—Rye is less affected by diseases and insects than the other small grain crops. There are no important insect enemies peculiar to the rye crop, although all the wheat insects attack rye also, but are usually less injurious.

Rye is injured by rust perhaps as much as oats or wheat, but is

never injured by smut. It has one peculiar disease known as ergot. The affected grains grow to three or four times normal size and turn black, being filled with black spores. It only rarely does serious injury. Ergot has a medicinal value, but it is dangerous to feed rye containing ergot to farm animals.

EXERCISE

Moisture in Grain.—Samples of rye and other grains kept under different conditions should be studied for moisture content as described in the exercise at the close of Chapter II. Secure samples from open bins, closed bins, newly threshed from stacks or shocks.

What does the exercise demonstrate as to best conditions of storage?

QUESTIONS

1. Where is rye cultivated?
2. Where is it more important than wheat?
3. Where cultivated in the United States?
4. Name the distinguishing characters of the rye plant.
5. Why can light bread be made from rye or wheat?
6. Give the types of rye.
7. What are the best climate and soil for rye?
8. Describe some rotations where rye is found useful.
9. Why are rye and vetch good crops for green manure?
10. Name the season when rye may be sown.
11. Explain curing of rye straw.
12. Why is rye straw so valuable?
13. How important is rye as a bread crop?

CHAPTER XXV

BUCKWHEAT

BUCKWHEAT is a crop comparatively small in acreage and production in the United States, occupying less than one million acres annually. Less than four farmers out of every 100 report buckwheat as grown, while 50 farmers report wheat, and 80 farmers report corn. About four acres of buckwheat are grown on each farm reporting, while twenty-five acres of common wheat and twenty acres of corn is the average.

Buckwheat Production.—There is no available information regarding the world's crop of buckwheat, but it is cultivated in Japan, North Asia, and North Europe. In the United States buckwheat production reached its height in the sixties, then rapidly declined in the seventies, but has again gradually increased since, though it has not reached the production of 1866.

While the production of all other cereals has very largely shifted from the eastern States to the Middle West since 1850, buckwheat is the one cereal that has remained principally in the East (Fig. 73). For 50 years New York has been the leading buckwheat State, with Pennsylvania a close second. These two states produce about two-thirds of the buckwheat crop. Michigan, Maine, and West Virginia follow in the order named.

Buckwheat Production, 5-Year Average, 1906–1910

	Production, Bushels	Average yield per acre, Bushels
United States	15,896,600	19.6
New York	6,302,000	21.0
Pennsylvania	4,971,000	19.0
Michigan	814,000	14.3
Maine	607,000	29.3
W. Virginia	451,000	20.0
Virginia	351,000	16.9

The average price per bushel is about 53 cents.

Origin and History.—Buckwheat appears to have originated from certain wild forms found in Central Asia. It was not culti-

vated in ancient times, and has come into cultivation mostly since the beginning of the Christian era. Its present distribution is principally in the northern half of Asia and Europe, and northeastern United States. Canada also grows a small acreage. It is grown principally for human food.

Relationships.—Buckwheat belongs to a botanical family characterized by angular three-sided seeds, including the common sorrels, sour docks, and smartweed. Most of this group will flourish on wet or sour soils, better than most vegetation. The buckwheat seed is

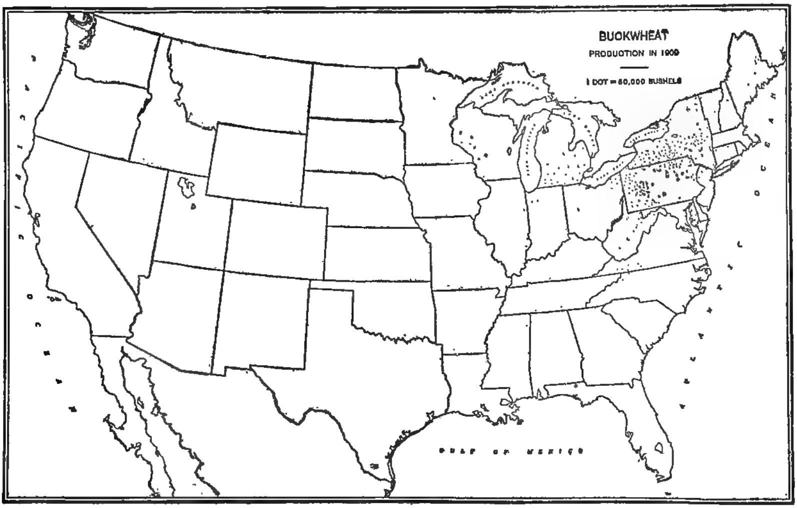


Fig. 73.—Distribution of buckwheat in United States. (U. S. Census, 1910.)

three angled like a beech nut, and the German name, *buchweizen,* and the Latin name, *Fagopyrum,* both mean "beech wheat." The German name has come to be "buckwheat" in English.

Description of Plant.—Buckwheat, perhaps, should not be called a true cereal, since it is not a grass (p. 2), but quite a different type of plant. Instead of a mass of fine fibrous roots, as in grasses, buckwheat has a strong central tap-root, with rather few branches. Neither does buckwheat produce tillers from the base, but strong lateral branches are thrown out at each node. When planted thin the lower branches are partly prostrate, but under ordinary field conditions the branching is much reduced and the plants stand quite

erect. The leaves are triangular and two or three inches broad. The stem varies in color from green to purple.

The flowers on ordinary buckwheat are small, but borne in compact masses at the end of small branches. However, in one species, the so-called India-wheat, the flower clusters are small and more scattered at the nodes along the principal stems. The flowers are of two types, one with long stamens and short styles, and the other with short stamens and long styles. Each plant produces only one type, but when the seed from either kind of plant is sown, both forms are produced in about equal numbers. This peculiar arrangement may assist in cross-fertilization.

The Buckwheat Grain.—The grain varies in color from silver-grey to brown or black. The outer cover or hull corresponds to the outer bran of wheat or corn, but differs in being much thicker and free from the starchy endosperm. The hull readily splits along the edges, and some care must be observed in threshing dry buckwheat not to thus hull too many of the grains. Old seed in dry storage will sometimes hull more or less. The endosperm is soft rather than hard, as in corn or wheat. The legal weight of buckwheat is ordinarily 48 pounds per bushel, though in different States it varies from 40 to 56 pounds.

In composition, the buckwheat endosperm is more starchy than wheat or corn, and is also low in fat content. In milling, the flour produced is very low in protein (six to seven per cent) and fat, but the middlings, which contain the germ, are distinguished by extremely high protein and fat content. The middlings are highly valued as stock feed.

The following data compiled by Hunt give average composition [1]:

Essential Ingredients of Buckwheat and Its Products

	Grain	Flour	Middlings	Hulls
Water	12.6	14.6	12.7	10.1
Ash	2.0	1.0	5.1	2.0
Protein	10.0	6.9	28.1	4.6
Crude fiber	8.7	0.3	4.2	44.7
Nitrogen-free extract	64.5	75.8	42.2	37.7
Fat	2.2	1.4	7.7	0.9

[1] Hunt, T. F.: Cereals in America, p. 402.

Classification.—There are three species of buckwheat in cultivation (Fig. 74):

1. Common buckwheat (*Fagopyrum esculentum*).
2. Tartary buckwheat (*Fagopyrum Tartaricum*).
3. Notch-seeded buckwheat (*Fagopyrum emarginatum*).

The three types are easily distinguished by the shape of grain. In the common buckwheat the grains are about as broad as long and smooth. The Tartary seed is longer than broad in shape, the edges wavy and seed slightly corrugated. The notch-seeded buckwheat has extended wings on the margins, giving the seed the appearance of being larger than the two above, though in reality it is not.

FIG. 74.—Types of buckwheat grain. From left, Tartary, Silver Hull, Gray and Japanese buckwheats.

Common Buckwheat.—Common buckwheat may be divided into three varieties, known as Silver Hull, Gray, and Japanese. Silver Hull seed is lightest in color while the plant and seed are smallest in size. The Japanese seed is brown to black in color, and both seed and plant largest in size. The Gray is intermediate in characters. Ordinarily Silver Hull is plumper, smoother, and heavier in weight per bushel than the other two.

In yield per acre, the Japanese usually exceeds the Silver Hull or Gray, and at present is most extensively grown. It is not uncommon for growers to mix the Silver Hull and Japanese, as it is thought, in case of hot, dry weather, the taller Japanese will protect the blossoms of the smaller variety and insure against blasting of the flowers.

Tartary Buckwheat.—This is commonly called India wheat. It is adapted to high and cool latitudes, especially mountainous districts. It is cultivated some in Maine, eastern Canada, and the mountain districts of New York.

Notch-seeded buckwheat is not cultivated in North America, but is said to be cultivated some in North India.

Climate for Buckwheat.—While buckwheat will grow a large crop of straw on good soil, in any temperate climate, yet it will seldom set seed well under hot or dry conditions. The flowers are said to be blasted; that is, after blooming freely the flowers die but no seed appears. Comparatively cool summer weather and sufficient rain to keep in healthy growth, favor a good set of seed. Such climatic conditions are most common in northeastern United States, especially in the rather high and hilly portions. It will be noted that buckwheat culture follows, in a general way, the hilly and mountainous region extending from New York through Pennsylvania and the Virginias. Being a very quick-growing crop it can be sown in mid-summer, thus bringing the blossoming into the more favorable fall weather.

Buckwheat also has another advantage over other cereals in wide adaptation to climate. It will continue to blossom for several weeks, so that a period of favorable weather occurring at any time during this period may result in a good set of seed.

Soils for Buckwheat.—Buckwheat has long been noted as one of the crops that will do fairly well on poor soils, if the climate is favorable. It will also do better than most crops on soils lacking in lime and drainage. This is one reason for its extensive culture in the hill lands of the eastern States.

While buckwheat will do well on productive soil, it is there brought into competition with other crops, as wheat or corn, and would ordinarily not be as profitable. Competing crops are always an important consideration in determining whether a crop will be grown or not.

Fertilizers.—Buckwheat responds readily to applications of fertilizer or manure. Usually manure is reserved on the farm for some other crop, but a moderate use of fertilizer on buckwheat is quite as common as for other crops. About 100 to 200 pounds per acre of a 4–8–5 grain fertilizer is considered profitable, but on the

land where buckwheat is generally raised it would not be considered wise to fertilize heavily.

Preparation of Land.—Often buckwheat land is poorly prepared, as it is sown late and other crops are cared for first. Late plowing is common, yet no crop responds better to early plowing and thorough preparation even though sown late.

Time of Seeding.—As buckwheat will mature in 60 to 70 days from sowing, it may be sown just late enough to mature before frost. The fall season is usually more favorable than the summer season for maturing the seed crop. The average time of sowing in New York and Pennsylvania is July 1, though it extends from June 15 to July 15. Harvesting is generally in the third week of September.

Sowing the Seed.—The ordinary rate of seeding is three to four pecks per acre, though it varies from two to five pecks. The seed grows easily, and since the plants grow rapidly, branching out to occupy all the land, there is little difficulty in securing a good stand.

The seed is commonly sown broadcast and harrowed in, though if the weather is dry and the land weedy, drilling is much better.

Harvesting.—As buckwheat continues to blossom and set seed until frost, it is usually cut when the largest yield of ripe seed can be secured. Ordinarily this is 60 to 80 days after sowing, but, in general, the crop is cut just before killing frost.

In dry weather the grain shatters off easily, so it is good practice to cut on a damp day or early in the morning. It is not usually bound as other grain, but cut with a self-drop reaper, which leaves the straw in loose gavels. As the straw is green and cures slowly, it may be left in gavels for several days. It is then set up without binding, but a handful of straw is twisted about the top, and two or three bunches set together.

Threshing.—Buckwheat is seldom stacked or put in a barn, as the straw does not readily dry enough to stack without great danger of heating. It threshes very easily and may be threshed when slightly damp. As the seeds are likely to crack, and the straw break up, the concave teeth are often removed from the threshing machine and boards or smooth concave plates inserted.

Uses of Buckwheat.—Buckwheat has been used from earliest times as human food. In America its principal use as human food

is in the form of griddle cakes, very common in country districts. A considerable portion of the crop was formerly fed to stock, and is used thus at present when the price is low.

When buckwheat is ground about 50 to 60 per cent is recovered as flour, about 25 per cent middlings, and a somewhat less percentage of hulls. The middlings are highly prized as stock feed, but the hulls have little value.

Buckwheat is considered to have special merit as a poultry feed. Beekeepers have long recognized it as producing an abundant and superior grade of honey.

Buckwheat straw has little feeding value, but is considered valuable as a mulch. It rots down so quickly that an old stack of buckwheat straw is often hauled directly on the land as manure.

Buckwheat as Green Manure.—Owing to its growth on poor land, buckwheat is often recommended as a green manure crop. It may be sown after a rye crop is plowed down, and either harvested or turned under. Rye and buckwheat may be sown together in July, the buckwheat harvested and the rye allowed to grow and be plowed down as green manure the following June. This may be repeated year after year on the same land, gradually increasing the humus supply of the soil, and meantime paying expenses with the buckwheat crop. In Virginia crimson clover is sown with buckwheat in the same way.

QUESTIONS

1. How important is the buckwheat crop? Where grown?
2. What wild plants is buckwheat related to?
3. Compare the plant with other cereals.
4. Describe the flowers.
5. Describe the grain.
6. How does it compare with wheat in composition?
7. Name and describe the three principal types.
8. Of the common buckwheat what are the three principal varieties? How distinguished?
9. Where is Tartar buckwheat grown?
10. Describe the climate favorable to buckwheat.
11. What advantages does a short-growing period and a long-blossoming period give to buckwheat?
12. Why is buckwheat grown on poor soils as a general rule rather than on good soils?
13. Does it respond to fertilizer?
14. Compare time of sowing with other cereals.
15. Describe method of harvesting.
16. Give the principal uses of buckwheat.
17. What is its value as a green manure crop?

CHAPTER XXVI

COTTON[1]

COTTON is the greatest of all fiber crops. It provides the principal articles of clothing for mankind. Of the four great staples from which clothes are made—cotton, silk, wool, and flax—cotton is rapidly superseding the others. It is easy to grow, easy to manufacture, and its finished product is cheap. And from no other crop are derived so many useful by-products.

Cotton is the leading cash crop of our country. Its imperishable nature renders it proof against depreciation in storage and it is the only important crop, with the exception of tobacco, which is converted directly and entirely into money.

World Production of Cotton.—The production of cotton is confined to warm countries. Previous to the first quarter of the nineteenth century, India was the leading cotton-producing country and a considerable part of the world's crop was also grown in Egypt. Since 1830, however, the production of cotton has centered in the southern part of the United States. At the present time the southern States produce three-fourths of the total cotton crop of the world. This is shown by the following table, which includes in round numbers the average for the crops of 1911, 1912, 1913:

Countries	Bales
United States	14,500,000
India	3,300,000
Egypt	1,500,000
Other countries	1,200,000
Total	20,500,000

Cotton Production in the United States.—Although climatic conditions restrict the commercial production of cotton to a group of States constituting less than one-fourth of the total area of the country, yet in value the annual cotton crop is exceeded only by corn and hay. Since the hay crop is composed of many different grasses and legumes, corn may be considered the only plant from which a crop is

[1] Prepared by Dr. W. C. Etheridge, Florida Agricultural College.

produced that exceeds the cotton crop in value. Among the eight leading crops of the United States, the cotton crop ranks much higher in percentage of total value than in percentage of total acreage. This is shown by the following table drawn from the average acreage and value of each of these crops for the years 1911, 1912, 1913:

Crop	Per cent of total value
Corn	34.9
Hay	16.6
Cotton	16.3
Wheat	14.4
Oats	9.0
Potatoes	4.6
Barley	2.2
Tobacco	2.0
Total	100.0

Crop	Per cent of total acreage
Corn	36.3
Wheat	17.1
Hay	16.8
Oats	13.0
Cotton	12.3
Barley	2.7
Potatoes	1.4
Tobacco	0.4
Total	100.0

Cotton Production by States.—The American cotton crop is produced almost entirely by ten States. These are the following, arranged in order according to their average crop of 1912, 1913, 1914:

State	Per cent of American crop	State	Per cent of American crop
Texas	30.5	Oklahoma	7.1
Georgia	15.5	Arkansas	6.6
Alabama	10.4	North Carolina	5.9
South Carolina	9.3	Louisiana	2.9
Mississippi	8.2	Tennessee	2.4

Other southern States combined produce only 1.2 per cent of the total crop.

Thus it is seen that the American cotton crop is fairly distributed within the territory lying south of a line running west from the southeast corner of Virginia to the northwest corner of Oklahoma and thence south along the western border of Texas. In certain States of this territory the production of the possible amount of cotton is not reached by reason of the interposition of other crops. Thus, in North Carolina and Tennessee tobacco supersedes cotton to a considerable extent, while in Louisiana sugar cane and rice are extensively cultivated. Above the southern border of Virginia the production of cotton for commercial purposes is prohibited by the cool climate. West of Texas the light rainfall is a limiting factor, although small amounts of cotton are produced in certain areas.

Early History of Cotton.—Cotton is a tropical plant, which is adapted also to the semitropic and mild temperate regions. The history of the plant, both as to its origin and as to its first use, is obscure. For ages, we know, it has been a native of the tropical parts of both hemispheres. India, it appears, as early as 1500 B.C. was the center of an important cotton industry. Many centuries before the Christian Era, the Egyptians, Greeks and Phœnicians had reached an advanced stage in the artistic spinning and weaving of cotton fiber.

Although a knowledge of the cotton plant and its usefulness spread gradually to China, Japan, and Southern Europe, the culture of the plant and the manufacture of cotton cloth seem not to have been practised in early times by the people of these countries. Silk, linen, and wool were preferred, and cotton cloth was used only when brought from India. Even in the Middle Ages the countries of Southern Europe had not engaged in the production and manufacture of cotton. Spain and Turkey were the first to enter this industry. In the fourteenth century Granada, Spain, was noted for its cotton cloth. From Spain and Turkey the use of cotton spread to other countries of Southern Europe and advanced gradually northward. By the middle of the eighteenth century England had developed an important trade in cotton and was beginning to import the raw material from America.

History in America.—Columbus found the cotton plant growing in the West Indies. Other explorers in the early part of the sixteenth century found cotton in Mexico, Peru, and Brazil. In these countries the fiber cotton provided the chief articles of clothing. In a word, cotton was known and used in what are now the Latin American countries at the time of the settlement in North America by the English. But, strangely, the aborigines of the section now comprising the cotton belt of the United States seem not to have known or used cotton. It is, therefore, doubtful that the plant is indigenous to any part of the United States.

The early colonists of Virginia, bringing seed from Europe, soon began the culture of cotton and there is evidence that in the latter half of the seventeenth century they made cotton cloth. Cotton is

mentioned among the products of Carolina in 1666, and by 1708 it is said to have become one of the principal commodities of that colony. By about the middle of the eighteenth century the culture and use of cotton had extended to Georgia, Florida, Alabama, Mississippi, and Louisiana, the seed being brought from all quarters of the globe. In 1786, Thomas Jefferson in a letter said:

"The four southernmost states make a great deal of cotton. Their poor are almost entirely clothed with it in winter and in summer."

Invention of the Cotton Gin.—The export movement of cotton began in the middle of the eighteenth century and in 1793, the year before Eli Whitney patented his saw gin, about 2000 bales were sent abroad. In the same year 22,222 bales were produced. In 1796, a year after Whitney had improved his machine, about 45,000 bales were grown and one-half of this amount exported. The invention by Richard Arkwright in England, 1796, of a machine for spinning cotton had created a great demand for the raw fiber, and Whitney's gin, which separated the fiber from the seeds, made possible a greater supply. Thus we see the stimulus of a great industry in the invention of the two machines. Within one hundred years, from 1790 to 1890, the production of cotton in the United States increased from 5000 bales to over 10,000,000 bales, and cotton became the great southern crop.

Cotton Manufacture in the United States.—The development of cotton manufacturing as a great national industry began with the first cotton mill, built in Massachusetts in 1788. This was soon followed by others in various parts of the eastern border of the country. In them carding and spinning was done by machinery, but weaving was by hand-looms until 1815, when a power-loom was built, also in Massachusetts. The manufacture of cotton rapidly increased until, in 1860, there were more than one thousand mills capitalized at about one hundred million dollars, using each year more than four hundred million pounds of raw material, and turning out annually a finished product valued at nearly one hundred and sixteen million dollars. During the great "cotton famine" caused by the Civil War the production and manufacture of cotton in the United States practically ceased, and it was not until 1868 that the cotton industry

regained its position of 1860. To-day the manufacture of cotton in the United States is by far the greatest industry related to American agriculture.

Classification.—The cotton plant belongs to the genus *Gossypium,* a member of the Mallow family. The number of its botanical speciés is variously stated as from four to eighty-eight. However, all authorities agree that the cotton of commerce is the product of only a few species. Parlatore names seven species, as follows:

1. *Gossypium Barbadense,* the long-stapled Barbadoes, Sea Island, Egyptian, and Peruvian varieties.
2. *Gossypium herbaceum,* the varieties of India, Siam, China, and Italy.
3. *Gossypium hirsutum,* the American upland varieties.
4. *Gossypium arboreum,* found in Ceylon, Arabia, South America, etc.
5. *Gossypium Peruvianum,* the native varieties of Peru and Brazil.
6. *Gossypium Tahitense,* found chiefly in Tahiti and the Society Islands.
7. *Gossypium Sandwichense,* found in the Sandwich and adjacent islands.

Species Grown in the United States.—In the United States *G. hirsutum* and *G. Barbadense,* embracing, respectively, the upland and Sea Island varieties, are the only species cultivated commercially.

Upland Cotton.—Although it is probable that American upland cotton is derived from the blending of several species, the present predominating type resembles more closely *G. hirsutum* than any other species. Hence, *G. hirsutum,* a native species of Mexico, is commonly thought to include both the short-staple and long-staple upland cotton of the United States.

Varieties.—American upland varieties are of two principal classes, namely, short-staple and long-staple (Figs. 75 and 76). There is another class, transitional with either of the foregoing classes, called "Benders" or "Rivers"—the names signifying any common type grown on rich, moist bottom lands and hence pro-

ducing an unusually long staple. This latter class is merely a commercial grade. The short-staple and long-staple classes may be distinguished by the longer lint, the more slender and sharper pointed bolls and the later maturing period of the latter class.

Number of Varieties.—There are very many varieties of upland cotton, most of them differing but slightly and being only tem-

FIG. 75.—An American short-staple upland variety, Culpepper.

porarily modified by environment. Many others are the result of crossing, both natural and artificial, and the segregation of individual types. Very often a group of so-called varieties are merely a single type represented by different names. At the Alabama Experiment Station most of the upland varieties were collected and classified, and while many of them were found to be identical there were

probably not less than one hundred which differed by one or more characteristics.

Classification of Varieties.—The classification of the upland groups, by Duggar, is here given, with slight modifications in description:

1. *Cluster Type.*—Plants slender with long basal limbs and extremely short middle and upper fruiting limbs; bolls small and tending to grow in clusters; seeds small to medium and thickly covered with fuzz. The plant has a special tendency to drop its fruit. Example: *Jackson.*

Fig. 76.—An American long-staple, upland variety, Allen's Early.

2. *Semicluster Type.*—Plants with general appearance of the cluster type, but with somewhat longer fruiting limbs; bolls of various sizes, borne close together but not in clusters; seeds of various sizes. Example: *Hawkins.*

3. *Rio Grande Type.*—Plants with slender, long-jointed limbs; leaves unusually small with narrow, sharp-pointed lobes; bolls small to medium; seeds small, dark, smoky-brown, and almost without the short fuzz common to other varieties; proportion of lint to seed unusually high—35 to 40 per cent of the weight of the lock-cotton. Example: *Peterkin.*

4. *Early Type.*—Plants small, with long, slender, usually crooked fruiting limbs; basal limbs short or wanting; leaves similar to those of the Rio Grande type; bolls small; seeds small and covered with fuzz of different shades; fiber short; blossoms usually marked with

a purple-red spot near the inner base of each petal; seed-cotton falls easily from the fully opened pods. Example: *King.*

5. *Big-boll Type.*—This type is characterized by its extremely large bolls—sixty-eight or fewer mature bolls yielding one pound of seed-cotton. It may be divided into the following transitional subtypes:

(*a*) Storm-proof, big-boll varieties. Example: *Triumph.*

(*b*) Big-boll varieties of the shape which characterizes the semicluster type. Example: *Truitt.*

(*c*) Big-boll varieties having neither marked storm resistance nor semicluster shape of plant. Example: *Russell.*

6. *Long-limb Type.*—Plants extremely large, with long, woody limbs, which have long internodes. No productive variety is included in this class and the type is disappearing.

7. *Intermediate Type.*—In this class may be placed varieties the group relationship of which is uncertain.

8. *Long-staple Upland Type.*—Plants tall and usually of a semicluster type; bolls rather slender and usually especially susceptible to injury from boll-rot (*anthracnose*); seeds densely covered with white fuzz; fiber long, but weak, and in small proportion by weight to the seed. Example: *Griffin.*

The foregoing upland types produce all of the cotton crop of the United States except the small amount of Sea Island cotton grown near the South Atlantic and Gulf Coasts. The staple of upland varieties is used in the manufacture of the coarser cotton fabrics.

Sea Island Cotton.—The Sea Island cotton (*G. Barbadense*) is grown on or near the coast of South Carolina, Georgia, and Florida. The plant is characterized by its extreme height, and long, slender, smooth branches; by its yellow blooms with their red spots near the base of each petal; by its rather small, slender bolls; and by its long, fine fiber and naked black seeds. The fiber of Sea Island cotton is longer than that of the upland varieties. It is fine and silky and is spun in the finest yarns and used largely for the manufacture of threads, laces, cambrics, and fine hosiery.

Description of the Cotton Plant.—All the common species of cotton are perennial in frostless climates, but in cultivation they are

usually treated as annuals. The plants are tap-rooted, erect, shrub-like and rather woody. The branches are in pairs, spreading and strongly jointed; and the stems and branches are in most species covered with delicate, whitish hairs. The leaves are three to five lobed. In upland varieties the flowers are white, turning red on the

Fig. 77.

Fig. 78.

Fig. 77.—The flower of upland cotton, viewed from the side, showing the bracts, calyx, and petals (after Cook).

Fig. 78.—Showing the "squares" of cotton—the unopened buds enclosed by the bracts (after Cook).

second day of blooming, but Sea Island cotton has yellow flowers with a purple-red spot at the base of each petal. The flowers are surrounded by three to five deeply fringed bracts (Fig. 77)—the number corresponding to the number of cells in the bolls. Previous to the opening of the blossom, the enclosing bracts form the so-called "squares" (Fig. 78). The bolls are irregularly oblong or oval in shape and are somewhat pointed. They have three to five cells and

at maturity they burst open and the locks of fiber, attached to the seeds, are easily gathered (Fig. 79).

Since the fiber and seeds constitute the cotton *crop,* it is important to consider them separately and in greater detail.

Fiber.—The fiber constitutes about 10 per cent, by weight, of

A B C D

FIG. 79.—Showing the opening of the cotton boll; and the lock-cotton, or seed-cotton; *A*, the unopened boll; *B*, the boll partly opened; *C*, the boll fully opened, and the locks of fiber; *D*, the empty pod after the lock-cotton has been gathered.

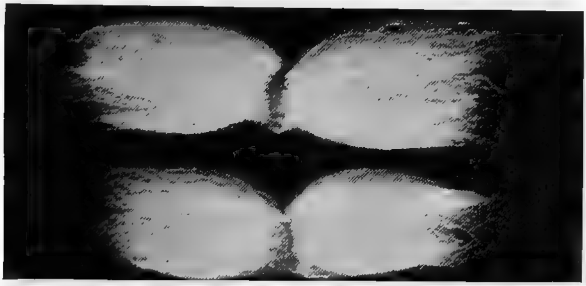
the mature plant. It is poor in fertilizing constituents, a bale of lint (500 pounds) containing only:

Nitrogen	1.7 pounds
Phosphoric acid	0.6 pound
Potash	2.3 pounds
Lime	1.6 pounds

Proportion of Fiber to Seed.—The proportion of fibers to seeds in lock-cotton is usually 33 to 35 per cent of the total weight, although extreme proportions of 30 to 40 per cent are often found. The production of a large proportion of fiber is a very desirable varietal characteristic.

Dimensions and Strength of the Fiber.—Each cotton fiber is a tubular, hair-like cell 0.001 to 0.025 inch in diameter. Its length varies among different species and varieties. The average length of the fiber of American upland short-staple varieties is from 0.80 to 0.95 inch, while in long-staple varieties it is from 0.90 to 1.50 inches (Figs. 80 and 81). The fiber of Sea Island cotton is

usually from 1.50 to 2.00 inches in length. The tensile strength of the fiber is estimated by the weight required to break a single strand. This is usually 6 to 8 grams, but extreme breaking weights of 4 to 14 grams have been found. A fiber of cotton is about three times as strong as a strand of wool in proportion to size.



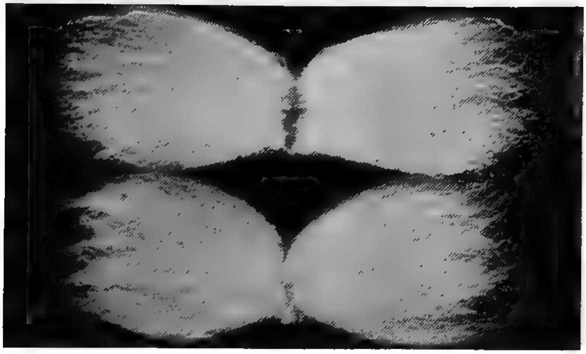


FIG. 80.—The fiber of an upland short-staple variety.
FIG. 81.—The fiber of an upland long-staple variety.

Classification of Fibers.—In every lot of cotton there are three classes of fibers (Fig. 82)—(1) unripe, (2) half-ripe, (3) ripe. These may readily be distinguished by observing with a microscope the extent to which they are twisted. The unripe fiber is cylindrical and tubular in form for most of its length. It is transparent, somewhat turgid and shows little or no twist. As the fiber ripens its tubular form collapses and contracts until finally it is much like a twisted ribbon with somewhat thickened and corrugated edges.

Only the ripe, twisted fibers are fit for perfect spinning and dyeing. The flattened and twisted form of the cotton fiber makes it particularly useful for the manufacture of cloth. No other vegetable fibers are like cotton in this respect. As compared with wool, the cotton fiber is smooth and twisted, while a strand of wool is straight and its edges are scaly.

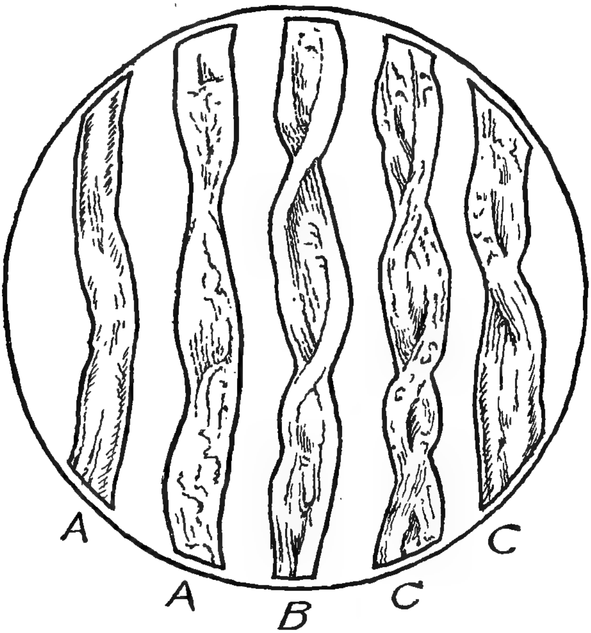


Fig. 82.—Showing the three classes of cotton fibers: *A*, **unripe;** *B*, **half-ripe;** *C*, **ripe (after Bowman).**

Desirable Qualities of the Fiber.—The value of cotton fiber is determined by its color, length, tensile strength, ripeness, fineness, and uniformity. The lint which grades highest in these respects is spun into the finer and more expensive cotton fabrics.

Seed.—About 20 per cent of the weight of the dried, mature plant is in the seeds. The average number of seeds in the usual four-celled boll is from thirty-five to forty; but there is considerable variation, depending upon the number of cells in the boll and the vigor

of the plant. The proportion of seeds in lock-cotton is usually about two-thirds of the total weight.

Fertilizing Constituents in the Seed.—The seeds of cotton, unlike the fiber, are rich in fertilizing constituents. In 1000 pounds of seeds, which is approximately the complement of 500 pounds of lint, there are the following amounts of plant food elements:

Nitrogen	31	pounds
Phosphoric acid	13	pounds
Potash	12	pounds
Lime	2.5	pounds

Covering of the Seed.—Beneath the long fibers, the seeds (Fig. 83) of most upland varieties are densely covered with a short fuzz, which may, according to the variety, be gray, green, or brown. However, there are a few varieties the seeds of which are almost free from this covering. The Peterkin variety, which has naked brown or black seeds, is a notable example of this type. In Sea Island cotton, also, the seeds are nearly or quite naked after the long fibers are removed.

FIG. 83.—Showing two types of cotton seed: *A*, seeds with a short, fuzzy covering; *B*, smooth, or naked seeds.

Weight Per Bushel.—The legal weight of a bushel of seeds is usually either 33 or $33\frac{1}{3}$ pounds, although naked seeds, that is, those lacking the fuzzy covering, are several pounds heavier. The naked, smooth, Sea Island seeds usually weigh about forty-four pounds per bushel.

Structure of the Seed.—The general structure of a cotton seed is very simple. There are only two main parts—the rough outer hull, or seed-coat, and the kernel. The kernel is somewhat shrunken and is easily removed from the hull. It consists mainly of two fleshy seed leaves folded around the embryo, or young plant. From the seeds are derived the valuable by-products of the cotton crop—feeds, fertilizer, and oil.

By-products of Cotton.—The products of the cotton plant do

not consist wholly of clothing made from the fiber. Fertilizer, oil, and feeds for animals are derived as by-products from the seeds and represent a large part of the total value of the crop.

Production of Oil and Cake.—The seeds are composed of about equal proportions by weight of hulls and kernels. After they have been separated from the hulls, the kernels are heated and pressed. Cottonseed oil and cottonseed cake are the products. A ton of cotton seed will usually yield about 300 pounds of oil, 750 pounds of cake and 800 pounds of hulls, the remaining 150 pounds representing evaporation and waste materials.

Cottonseed Meal.—The cottonseed cake is usually ground into cottonseed meal, although it may be used as feed without being ground. Cottonseed meal is very valuable, either as feed or fertilizer.

Constituents of Cottonseed Meal.—The following table will show the richness of cottonseed meal in the principal feed and fertilizing constituents:

Principal feed constituents	Average percentage contained in cottonseed meal
Protein	44
Nitrogen-free extract	21
Fat	14
Fiber	5
Principal fertilizing constituents	
Nitrogen	7
Phosphoric acid	3
Potash	2

Use of Cottonseed Meal as Feed.—Cottonseed meal is an excellent concentrate with which to supplement the roughage fed to sheep and dairy cattle, but it is little used as a feed for horses. It has a specific toxic effect on hogs and when fed in quantity will cause their death within periods of from five to seven weeks. Cottonseed meal is probably injurious to most other young animals, particularly to calves.

Use of Cottonseed Meal as Fertilizer.—The great value of cottonseed meal as a feed for dairy cattle has in recent years caused the price of this material rapidly to advance. At present prices cottonseed meal, although an excellent nitrogenous fertilizer, will give

larger returns in money when fed to dairy cattle or to fattening steers than when applied to the soil.

Cottonseed Oil.—Cottonseed oil is almost identical in composition with olive oil. Its various grades are used as salad oils and cooking oils, as a lubricant, and in the manufacture of oleomargarine, soaps, and paints.

Cottonseed Hulls.—Cottonseed hulls are tough, woody material and are used in the manufacture of paper and fiber-board from which are made trunks, gear-wheels and many other useful articles. They are often used as a feed for dairy cattle, but they are poor in fats and protein and are usually supplemented with cottonseed meal. Their ash, however, is rich in fertilizing constituents—potash, phosphoric acid and lime—and is a valuable fertilizer, although little used.

CHAPTER XXVII

COTTON CULTURE

Climate.—Cotton is a delicate, sun-loving plant. It requires for its development a long, warm growing season of six or seven months, during which the rainfall is evenly distributed.

Length of Growing Season.—One of the most important features of a climate suited to the growth of cotton is the probable date of the last killing frost in spring and of the earliest frost in autumn. Unless there is a frostless period between these dates of at least 180 days the fullest development of the plant in all of its functions will not be attained, for while the harvesting of cotton often extends far into winter, the first killing frost of autumn checks the active growth of the plant, and the blossoms and the bolls formed at this time will not develop mature fiber (Fig. 84).

Amount and Distribution of Rainfall.—The amount and distribution of rainfall has a very important bearing on the success of the crop. The cotton plant thrives best during a season marked by light, frequent showers, preferably at night, so that there may be the maximum daily amount of sunshine. Heavy, frequent rains during that period in the life of the plant from the thinning or "chopping out" process to the formation of the first bolls will cause a too rapid development of the vegetative parts to the detriment of a normal formation of the flowers and fruit. If rains are too frequent during the latter part of this period, the unopened flowers, or "squares," drop from the plant in great numbers and its yield is consequently decreased. Also, boll-rot (*anthracnose*) is more prevalent in rainy seasons than in others. During the picking season, if heavy rains occur, a considerable amount of the lint is discolored, or even beaten from the open pods and lost.

Temperature.—The temperature of the growing season should be high and its daily range uniform during the early life of the plant. Either a great and sudden rise in temperature or a prolonged coolness during this period is liable to check the vegetative

growth and hasten an undesirable premature ripening. After the first part of August, however, when the plant has attained its full vegetative growth, a lower and more varied temperature is desirable. Cool nights at this period favor the production of a maximum crop, for the lower temperature checks the vegetative growth and hastens the maturation of the seeds and fiber.

Region Suited to Cotton.—The cotton belt of the United States is the area between 37° latitude and Gulf Coast and east of the western border of Texas. The heavy frosts of this section have generally

FIG. 84.—A field of upland cotton in September.

ended by the middle of April, and if cotton is planted in time to show above ground by the first of May there is little danger of it being frost-killed. The frosts of autumn generally do not come before the middle of October or the first of November, and the plant has six to seven months of warm, frostless weather in which to produce its crop. The average mean temperature of the cotton belt, from April to October, inclusive, ranges from 71° F. in the northern area to 74° F. in the southern area. During the same period there are, on the average, in each 100 days about 56 which are clear and sunny, and 32 which are likely to produce rain. The climatic re-

quirements of the cotton plant are by these conditions ideally fulfilled.

Soils.—The upland cotton does not require a particular type of soil. It readily grows on all types if the conditions of climate are favorable. The cotton crop is produced with success on sandy soils, on loams, on the various types of clay soils, and on silty bottom-lands. However, the appearance of the plant is slightly modified and its yield is varied by the influence of different soils. On sandy uplands, the plant is small and inclined toward abundant fruitage, although its total yield is light. On heavy clay soils and on bottom-lands, the plant, in wet seasons, grows large and woody, fruiting lightly in proportion to its size but producing a greater total yield than when grown on light, sandy soils.

Most Favorable Soils for Cotton.—The soils which most often produce successful crops of cotton are medium grades of loam, containing 25 or 30 per cent of clay and about 40 per cent of silt. Such soils are porous, easily drained, and early warmed in the spring. They also are retentive of moisture, maintaining on the average 10 or 12 per cent of moisture throughout a growing season of a normal climatic tendency. The loams sometimes do not produce as large yields as do bottom-lands and the heavier clay soils, but their productiveness is more certain; they have a tendency to produce on the average a good crop under a wide variation in seasons, while the productiveness of other soils is more dependent upon seasonal fitness. It is not unusual, in wet seasons, for a cotton crop grown on a heavy clay or rich bottom soil to be so badly injured by the ravages of diseases and insects as to be accounted a failure, or to make such a rank vegetative growth that the fiber will not mature before the frosts of autumn.

Fertility of Cotton Soils.—In certain parts of the cotton belt, the cotton plant does not require for its most successful development an extremely fertile soil, such as is needed for the highest production of corn. A soil of medium fertility which will not cause the plant to make an excessive vegetative growth, and thus delay its maturity, is best for the production of cotton in the northern and central areas. Here, in the relatively short growing season, the timely maturation of the plant has a very important relation to a successful crop, and

larger total yields will usually result from soils which are sufficiently fertile to produce a well-matured crop but which are not rich enough to prolong past a normal maturing period the active growth of the plant.

In the northern area of the cotton belt it is sometimes better even to balance a deficiency in soil fertility by the addition of commercial fertilizer than to choose a rich, moist bottom-land which will produce a heavy vegetative growth at the expense of a matured fruitage.

In the southern area, however, the most fertile soils are preferable, for here the growing season is of a sufficient length to allow the maturation of a larger proportion of the fruit than is usually possible in the shorter season of the more northerly area. With the advantage of a longer growing season, during which most of the fruit set by the plant is matured, the total yield is somewhat proportional to the degree of soil fertility.

Soils for Sea Island Cotton.—The Sea Island cotton, unlike the upland variety, is not adapted to widely different soils. It is best suited by light, fine, sandy soils, which contain but small proportions of clay and silt. Soils of this character retain little moisture, and in that respect they are quite different from the best type of soils adapted to the upland cotton. In respect to its need of soil fertility, however, Sea Island cotton is like the upland variety. It is best adapted to soils of medium fertility which tend to produce a well-matured crop rather than to stimulate an extremely large vegetative growth.

Fertilizers.—The enormous increase since 1865 in the production of cotton in the United States is due chiefly to the use of commercial fertilizers. With the aid of fertilizers a large area of depleted soils in the cotton belt has been returned to a state of profitable productiveness.

Effect of Fertilizers.—When used for the production of cotton, the effect of fertilizers is twofold—(1) they increase the growth of the plant, and (2) they stimulate the plant to an early maturity.

By the influence of fertilizers in shortening the period of active growth of the plant, the northern limit of the area in which cotton

is profitably cultivated has been considerably extended. It is in the northern section of the cotton belt that the use of fertilizers is relatively greatest.

Need of Fertilizer for the Cotton Plant.—The cotton plant makes only a slight draft on the fertility of the soil. It is a delicate feeder, being in this respect much like wheat. The production of a bale of cotton weighing 500 pounds removes from the soil only about as much plant food as is contained in the grain alone of a 40 bushel crop of corn or of a 60 bushel crop of oats. Accordingly, a given amount of plant food, when transmuted into cotton, produces a crop twice or three times as valuable as when transmuted into corn or oats.

But while the cotton plant uses only a small amount of plant food, it requires this in a readily available form. It has not an extensive and vigorous root system like that of corn or of oats, and hence it has not like these plants the power to draw heavily from the soil. A part of its food must, therefore, be artificially supplied in an easily soluble form.

The Use of Commercial Fertilizers.—The cotton plant responds promptly to fertilization and, except on extremely poor sandy soils or very rich bottom lands, a judicious use of commercial fertilizer is usually profitable. Indeed, on upland soils of average fertility a crop of cotton grown without the aid of fertilizer, received either as a direct application or as a residue from an application to some other crop, will not usually give a profitable return for the time and money expended in its production.

Previous Treatment of the Land.—As with most other crops, the profit resulting from the fertilization of cotton is increased if the soil has previously been brought to a good condition of tilth and contains a store of organic matter left by the growth of leguminous or other green manuring plants.

Phosphoric Acid.—Extensive investigations by southern Experiment Stations have shown conclusively that phosphoric acid in some form should be used liberally in the production of cotton. It causes a larger increase in yield and it returns a greater profit from the money invested than any other element of plant food. An

application of phosphoric acid is generally more profitable when the material is in a readily available form, hence as a cotton fertilizer acid phosphate is preferable to the less soluble rock phosphate, or the Thomas phosphate, although the availability of the latter materials is increased by mixing or composting them with rotting organic matter, such as stable manure.

Nitrogen.—Although nitrogen usually causes an increase in the yield of cotton, it is the most expensive element of commercial fertilizer and its use is not always profitable. Nitrogenous fertilizers must therefore be used judiciously or their actual cost may not be returned in the increased yield which they produce. Generally speaking, the soils to which nitrogen is applied with profit are those of a medium natural fertility. An application of nitrogen to extremely poor sandy soils is wasteful, for the reason that fertilizer alone is not sufficient to raise the productivity of such soils to a profitable standard. On the other hand, the rich bottom-lands are so fertile that nitrogen is not needed, and its addition will usually not result in a profitable increase of the crop.

Sources of Nitrogen.—The organic forms of nitrogen, such as dried blood and cottonseed meal, supply nitrogen more cheaply than do the inorganic forms—nitrate of soda and ammonium sulfate. But by far the most inexpensive and profitable source of nitrogen for the cotton crop is the organic matter added to the soil by the growth of *leguminous crops*—cow peas, soy beans, velvet beans, clovers, and vetches. Indeed, the only rational system of cotton farming is one which includes the frequent production of a leguminous crop in its scheme of crop rotation, for this system not only adds in an inexpensive form nitrogen to the soil, but it also tends to conserve the soil's natural store of nitrogen.

Potash.—The southern soils are well supplied with potash and the cotton crop requires but small additional amounts of this element. Potash is profitable only when combined with nitrogen and phosphoric acid, and then only in small amounts. It has at times been found useful in counteracting or preventing black rust, a disease of cotton.

Sources of Potash.—The commercial fertilizers used as sources

of potash are kainit, muriate and sulfate of potash. Muriate of potash will usually furnish the potash element more cheaply than it can be purchased in either sulfate of potash or kainit.

Lime.—Lime, when used alone, has little or no effect on the growth of cotton, unless the soil is in a very poor physical condition and has a specific need for this material. However, when it is applied with a complete fertilizer the action of lime in rendering more available the other constituents may at times make profitable its use.

Combination of Fertilizers.—The cotton plant requires a balanced food. Hence the fertilizing elements are more efficient when combined in a complete fertilizer; that is, one containing balanced proportions of nitrogen, phosphoric acid, and potash. Of these elements, phosphoric acid is the most important and controls the effectiveness of the others.

Proportions of the Fertilizing Elements.—In the total amount of fertilizer the relative proportions which should be used of phosphoric acid, nitrogen, and potash, vary according to the needs of the soil. However, the usual proportions of these elements, in a complete fertilizer for cotton, are approximately, phosphoric acid 2½, nitrogen 1, potash ½.

Amount of Fertilizer.—The amount of fertilizer which may profitably be applied to cotton depends chiefly upon the character and previous treatment of the soil, and to some extent upon the season. On soils of an average fertility, 400 to 600 pounds of a complete fertilizer is usually the most profitable amount, but to include soils of all classes the limits of the application may at times range from 200 to 1000 pounds.

Method of Applying Fertilizer.—The general results of experiments in the methods of applying fertilizers to cotton show clearly that drilling is far more efficient than broadcasting, especially if small amounts of fertilizer are used. Fertilizers are drilled either by hand, using for the purpose a long funnel or "guano horn," or by a fertilizer distributor, which drills and covers the material in a single operation. They are usually distributed at a depth of 3 to 4 inches below the surface of the soil.

Time of Applying Fertilizer.—The usual time of application is at planting, although for light, sandy soils, from which the fertilizer may partly leach during heavy, protracted rains, a portion may be reserved for a second application at about the time the plant begins to set its fruit.

The Culture of Cotton.—The cultural methods for cotton, like those for any crop, are based on the fundamental principles of adaptation and conservation.

In so far as the methods of culture can modify the soil, they must be aimed to adapt it to the needs of the plant; the soil must be so managed as to fulfil the cultural requirements of the particular crop to be grown. At the same time the welfare of the soil itself must not be neglected. Soil management in the culture of any crop must include the principle of conserving the natural resources of the land and of leaving it in a good physical condition for the growth of succeeding crops.

Disposal of Old Stalks.—If cotton has been the preceding crop, and has made a rank, heavy growth, the first step in the preparation of the field is in so disposing of the old stalks that they may be plowed into the soil. They may be cut down by a specially designed stalk-cutter, a triangular frame which has cutting edges on two sides and is drawn between the rows of stalks; or they may be broken or flattened by dragging across them with a heavy drag, or by beating them with sticks. This may be done at any time during the winter months.

Cotton stalks should never be burned or otherwise removed from the soil, unless as a means of checking the spread of insects or diseases. They soon decay and add to the soil much valuable organic matter, which is a principal element of soil fertility.

Time of Plowing.—Land for the growth of cotton is usually plowed in February or in March, depending upon its climatic location. Within the limits of the season, the time of plowing is regulated somewhat by a consideration for the growth of the cover crop, if such be on the land, and by the amount of water in the soil. A properly drained soil can be plowed much earlier than one

which retains a considerable amount of free water from the rains of winter.

Method of Plowing.—The best method of preparing the soil for cotton is first to plow or break the land level; that is, to turn all the furrow slices in the same direction. Although it is a common custom in many sections to at once ridge or bed the land for planting by throwing together for each ridge usually four furrow-slices, a much better condition of the soil is reached if this operation is subsequent to that of a thorough level plowing.

The efficiency of the first plowing is much increased if the furrow-slices are cut narrow and even and are thrown well together.

Depth of Plowing.—The depth to which cotton lands should be plowed depends somewhat upon the character of the soil and the amount of vegetable matter which is to be turned under. Heavy clay or bottom-land soils should be broken to a depth of at least 8 inches. If the soil is very stiff and in poor physical condition, plowing to a depth of 10 inches will insure a better preparation. On sandy and loamy soils a more shallow plowing of 6 or 8 inches in depth is usually sufficient. These types of soils are usually in a better physical condition and are more readily brought to a state of good tilth than are soils of a marked clayey or silty character.

The depth of the soil regulates to a considerable extent the quantity of moisture which will be retained after a season of rains. It is therefore of great importance that the land be deeply and thoroughly broken by the preparatory process.

Disking and Harrowing.—It is often best after plowing to thoroughly disk and to harrow the land, thereby cutting and breaking the larger clods left by the plow. The heavier clay soils may require both of these additional treatments before they are in a satisfactory condition, but for the sandy and loamy soils the single process of harrowing is usually sufficient.

Importance of Thorough Preparation.—A land well plowed is the foundation for a good crop of cotton. The surface vegetable matter is more thoroughly incorporated with the soil, and its decay and consequently its addition to soil fertility is thereby hastened; the soil is made mellow and fit for planting; the moisture retentiveness

of the soil is increased; and, finally, by thoroughly breaking and pulverizing the soil in its early preparation, all subsequent tillage of the cotton crop is made easier.

Planting on Ridges or Beds.—It is the custom in most cotton-growing sections to plant the cotton crop on ridges or beds, which are usually three to four feet wide and several inches high. Each ridge is formed by throwing together four to six furrow-slices, the first two forming the "list" and the succeeding furrows completing the ridge or bed. If commercial fertilizer is to be used, a furrow is first run to contain the fertilizer over which the ridge is later formed. Planting may be done on the list formed by the first two furrows, thus leaving on each side an unplowed strip or middle later to be thrown or "bursted" toward the list; or the ridge may be completed at the first operation, thus leaving a clean middle.

Planting Level.—A more simple method of planting is one which omits ridging and places the seed in furrows which are run level with the adjacent surface by a single trip of a shallow plow of either the mould-board or bull-tongue type.

Level Culture vs. Ridge Culture.—The chief advantages and disadvantages of the level furrow and ridge methods of culture may briefly be summarized:

Ridge culture.

Advantages:

(1) On wet lands, ridges provide somewhat a system of drainage.

(2) On lands subject to washings, ridges, if run crosswise to the slope of the land, check the removal of soil.

Disadvantages:

(1) Ridges cause a greater evaporation of soil moisture than do the level furrows, since they expose a larger surface.

(2) They require more labor in their formation than do level furrows.

(3) They are less convenient than level furrows to cultivate.

Although in most sections of the cotton belt the ridge-culture

method is the one most commonly used, the level-furrow method is rapidly growing in favor.

Date of Planting.—In order to insure the longest possible growing period for the crop, cotton should be planted as early as the climatic restrictions of the locality will permit. The general rule is to begin planting within two or three weeks after the average date of the last killing frost. The following table by Shepperson gives the approximate dates when cotton planting begins and ends in the southern States:

States	Usual date to begin planting	Usual date to finish planting
North Carolina	April 15	May 10
South Carolina	April 15	May 7
Georgia	April 10	May 1
Florida	April 1	May 1
Alabama	April 5	May 10
Mississippi	April 5	May 10
Louisiana	April 1	May 10
Texas	March 15	May 10
Arkansas	April 15	May 15
Tennessee	April 15	May 15

The Process of Planting.—Cotton planting on a large or even a moderate scale is done by a specially designed implement, the cotton-planter, which opens the furrow, drops and covers the seed, all at one trip. The ordinary planter seeds but a single row at once, but there are other types which seed two rows, and still others, which having an attachment for drilling fertilizers, perform at one operation the processes of fertilizing and seeding.

Quantity of Seed.—Cotton is usually planted at the rate of 4 to 8 pecks of seed per acre, but of this amount only a relatively small number actually develop into mature plants. If each cotton seed of a bushel containing approximately 140,000 seeds were to become a mature plant, there would be a sufficient number of plants to provide a stand for 15 or 16 acres. However, in order to secure a good stand of the crop it is necessary to plant an excessive amount of seed. Many of the seeds fail to germinate and a large number of those which actually germinate do not survive, although there is still left for the thinning process a far greater number of vigorous young plants than are needed for a stand.

Thinning or Chopping.—The crop is thinned or "chopped" to

the desired stand when the plants are three to four weeks old, or just after the third or fourth leaf has appeared. The thinning is done with hand-hoes, cutting away the superfluous plants and at the same time clearing the rows of grass and weeds.

Spacing of the Plants.—Cotton rows are spaced at from 3 to 5 feet, and in the row the plants are usually left 12 to 20 inches apart. In thinning the plants to a stand it is best to leave at least two plants in each hill in order to provide against further loss.

The area provided for the growth of each plant is regulated according to the fertility of the soil and the type of the plant. Cotton, unlike corn, is crowded on poor land and spaced farther apart on rich land. The reason for this is that cotton is a wide-branching plant and on rich land requires much space for the lateral growth of its branches. By reason of their shorter branches the cluster types of cotton require less space in which to fully develop than do the wider branching types.

Cultivation.—The cotton plant is the least vigorous of all the important field plants and throughout its active growing period the cleanest and most careful cultivation is necessary to insure a successful crop. From the appearance of the third or fourth leaf to the formation of the bolls, the crop should frequently be cultivated.

Principles of Cultivation.—The main underlying principle in cultivating cotton is the removal of competitive plants, and hence the destruction of grass and weeds is the chief purpose of each tillage operation. While by cultivation it is important also to conserve the soil moisture and to cause a fine mechanical separation of the soil particles, these desirable conditions are incidentally fulfilled by thorough cultivation throughout the season for the destruction of grass and weeds.

Methods of Cultivation.—There is no fixed method of cultivating cotton. It varies according to the method of planting and to some extent upon the character of the soil. A cotton crop planted on ridges is cultivated somewhat differently from one planted in level furrows. Ridge-culture requires a greater use of shallow turn-plows and scrapes, or "sweeps," the latter implement being particularly effective on light soils. However, under both methods of

planting most of the cultivating is usually done with the ordinary frame cultivator, such as is used for cultivating corn and other crops. There is also often required throughout the season considerable weeding with hand-hoes, but the necessity for this is greatly lessened by the timely use of horse-implements.

Frequency of Cultivation.—The number of cultivations required to keep the crop clean throughout its growing period depends upon the character of the season and of the soil, and upon the timeliness and thoroughness of each tillage operation. Usually, a cultivation at each 10 day period, or soon after each rain, will be sufficient to

FIG. 85.—Cultivating the corn field with a weeder before the crop has come up. A similar implement is very useful for the early cultivation of cotton.

keep the crop free of grass and weeds and to preserve a well-mulched soil surface. However, if the rainfall is excessive, and the land extremely fertile, giving rise to abundant growths of weeds and grass, more frequent cultivation will be necessary.

Depth of Cultivation.—Usually, the depth of cultivation is 1 or 2 inches, although if a heavy crust is allowed to form a deeper tillage is required to break and mulch the surface.

Economy in Cultivation.—The most economical method of cultivating cotton is one which includes the use of the weeder, a light, long-toothed harrow, such as is sometimes used for the cultivation of corn (Fig. 85), and the use of two-row riding cultivators (Fig. 86).

When the plants are only a few inches high, the weeder may be run across the rows, breaking the soil to a shallow depth and thereby checking the early growth of grass and weeds. At the same time the soil surface is prevented from baking and cracking, with a consequent loss of moisture by evaporation. One or more cultivations with the weeder before the crop is thinned to a stand will greatly lessen the future growth of grass and weeds, and will therefore reduce the amount of hoe-chopping necessary at the time of thinning. After

Courtesy Planet Jr. Company

FIG. 86.—The use of two-row riding cultivators—the most economical method of cultivating large fields of cotton.

thinning, the most economical cultivation is by two-row riding cultivators, if the area of the crop is large enough to justify their use; otherwise, the use of single-row cultivators or sweeps is more economical (Fig. 87).

By the early use of the weeder, and by timely and thorough subsequent tillage with a two-row riding cultivator, the frequency of cultivation and the cost of each operation may be much reduced.

Harvesting.—From the field to the market the cotton crop passes through three processes—picking, ginning, baling.

Picking.—Cotton picking is the most expensive operation con-

nected with the production of the crop. It begins late in August or early in September and sometimes extends far into the winter, although the bulk of the crop is usually gathered by the middle of November. The cost of picking varies from 50 to 75 cents per 100 pounds of seed-cotton; this being equivalent to about 1½ to 4¼ cents per pound of lint. The amount of seed-cotton which one per-

Courtesy Planet Jr. Company

FIG. 87.—Cotton cultivation with a single-row cultivator which may be equipped with both sweeps and hoes.

son can pick in a day varies usually from 100 to 500 pounds, depending on the skill of the laborer and the yield of the plants.

Cotton must be gathered by hand, as no mechanical cotton-picker has yet been invented which gives satisfactory practical results.

Ginning and Baling.—A complete ginning outfit consists of an elevator, usually of the suction type, for removing the seed-cotton from the wagon to the gin, of one or more gins for tearing the lint from the seeds, and of a baling-press where the ginned lint is packed

into bales and covered with a coarse bagging. The cost of the ginning and baling processes is usually a dollar to a dollar and a half per bale. The bales of lint each usually weigh about 500 pounds. When to be shipped long distances, particularly transatlantic shipment, the bales are recompressed into smaller bulk.

Marketing the Crop.—The largest part of the cotton crop is sold to local buyers, usually storekeepers. However, the larger farmers may at times consign their crop directly to cotton merchants in the larger cotton markets.

Commercial Grades of Cotton.—The selling price of cotton varies within narrow limits according to the grade or quality of the lint. Cotton when sold by farmers is usually graded by the buyer, although in all later transactions between business firms both parties to the sale decide on the quality of the staple.

The points to be observed in grading cotton are the following:

(1) Amount of sand and trash.
(2) Color of the fiber.
(3) Percentage of immature fibers.
(4) Length and strength of the fiber.
(5) Dampness of the fiber.

On the basis of these points, the relative values of which are somewhat variable in different markets, the seven full grades of American cotton are as follows:

(1) Fair.
(2) Middling fair.
(3) Good middling.
(4) Middling.
(5) Low middling.
(6) Good ordinary.
(7) Ordinary.

The above system of grading is sufficiently refined for the smaller markets, but the larger cotton merchants differentiate also to the point of half and quarter grades. This further differentiation is determined by dividing each full grade into half grades, the best of which has the prefix "strict," and by subdividing the half grades into quarter grades, to which are given the prefixes "fully" and

"barely." Thus the grade "middling" would finally be classified as strict middling, fully middling, middling, barely middling.

The greater part of the upland cotton is classified according to the following grades which are arranged in the order of their value:

(1) Strict good middling.

(2) Good middling.

(3) Strict middling.

(4) Middling.

Destination of the Crop.—Most of the cotton crop of the United States ultimately reaches the mills of New England, Canada, and Europe. The larger cotton houses in the American trade have direct foreign connections. On the other hand, they have buyers at many of the small towns and railroad stations of their district, and thus the transfer of the crop from the farmer to the foreign market is completed. Although about one-half of the American cotton goods is manufactured in the Carolinas and adjacent States, by far the largest part of the crop is shipped as raw material out of the section in which it is produced.

Insect Enemies of Cotton.—Among the insects which damage the cotton crop the most important are the Mexican boll-weevil and the boll-worm. Others are the nematode worm, the cutworm, the cowpea pod-weevil, the red spiders, plant lice and caterpillars.

The Mexican Boll-weevil (*Anthonomus grandis*).—The boll-weevil is the most destructive of all insects to American cotton. In the southwest portion of the cotton belt, this insect at times reduces the crop by at least 50 per cent. The weevil is small, usually not more than ⅜ of an inch in length, and dark brown or black. Its attacks are confined almost entirely to the squares and bolls, which are eaten from without by the mature weevil and from within by the larvæ.

Preventive Measures.—The most effective practical measures of combating the boll-weevil are the following:

(1) Burning the old cotton stalks and other litter which harbor the insects through the winter.

(2) Forcing the crop to an early maturity, thus producing a large number of bolls before the weevils can attack.

(3) Rotating crops, by which means the insect is deprived of its food, since it eats no other widely grown plant but cotton.

(4) Fumigating the seed in order to prevent the introduction of the pest at planting.

The Boll-worm (*Heliothis obsoleta*).—The boll-worm is more widely distributed than the boll-weevil, although it is less destructive. It is a small, blue-green worm, with spots and black stripes on its back. It is hatched from the eggs of a moth. Like the boll-weevil, the boll-worm attacks chiefly the squares and tender young bolls.

Preventive Measures.—A trap-crop is the most widely used means of checking the attacks of the boll-worm upon cotton. Such a crop is one upon which the moths prefer to deposit their eggs. Their favorite depository is the fresh silks of corn, and hence corn, planted in strips at intervals among the rows of cotton, is the crop generally used as a trap. The corn should be planted late in order that it may be in silk at about the time the cotton plant sets its fruit.

The worms may be killed when young by spraying or dusting the plants with arsenical poisons. This is an effective killing method, but its use on an extensive scale is not practicable.

Diseases of Cotton.—The most serious diseases of cotton are boll-rot (*anthracnose*), cotton wilt, or black rot, and cotton rust, or black rust. Others are root-rot, root-knot, angular leaf-spot, leaf-blight, sore shin, and mildew.

Boll-rot.—This disease appears as grayish or pinkish spots on the immature bolls. Eventually the entire contents of the bolls may be rotted out.

Boll-rot is most virulent during wet seasons and at such times it may seriously damage the crop. It makes little progress in dry weather, and therefore an unfavorable condition for its development is created by spacing the plants widely, so that the maximum amount of sunshine will be admitted to the bolls. Certain varieties of cotton are partially resistant to boll-rot and such may be used to advantage in sections where the disease is widely prevalent. The selection of the seed of uninfected plants is also recommended as a means of checking the spread of this disease.

Cotton Wilt.—Cotton wilt comes from the soil. It is a thread-

like fungus growth, which enters the plant through the roots and interferes with the upward passage of water to the stems. It may attack the plant at any time after the leafing-out stage, but the height of its virulence is reached after the bolls have formed. The disease is indicated by a sudden wilting of the plants or by their dwarfed appearance. In either case the plants may shed their leaves and die, or may live in an unthrifty condition.

Wilt can only be controlled by burning infested plants, and by a rotation of crops through which cotton is kept from the land for three or four years.

Cotton Rust.—The black rust of cotton is perhaps the most destructive and widely distributed disease of the plant. It is a fungous disease which causes the leaves to become yellow or blackened and to fall from the branches. The development and maturing of the bolls is thus prevented and the crop is often seriously damaged.

On light sandy soils, the use of 80 to 100 pounds of kainit, which may be applied with other fertilizers, has been found a remedy for black rust. Under this treatment the plant retains its foliage until the bolls have matured.

LABORATORY EXERCISES

(1) Remove the bracts and petals of a cotton flower and make a drawing showing the stamens and stigmas. Why do cotton flowers so readily cross-pollinate?

(2) Compare the bolls of a short-staple variety with those of a long-staple variety. Make an outline drawing of a boll from each variety, showing the difference in their form. Compare the number of bracts with the number of cells, or compartments, in the boll. Are they equal?

(3) Straighten from the seed the fiber of a short-staple and of a long-staple variety (see Figs. 80 and 81). Compare the length of the two classes of fiber. Pull a few fibers of each class; twist those of each class into a string and note their comparative breaking strength.

(4) If microscopes are at hand, observe the three classes of fibers—unripe, half-ripe and ripe (see Fig. 82). Note the flattened twisted form of the ripe fibers. Separate a few fibers of each class; twist each lot into a string and compare their breaking strength. What are the desirable qualities of the fiber?

(5) Split a cotton seed and observe its simple structure. What are the general parts of a cotton seed?

(6) Compare, as to the proportion of opened bolls, a plant of an early maturing variety with one of a late maturing variety. Observe, as to structure and outline, the general difference between the two plants. Why is an early maturing variety of cotton especially desirable?

The following practices are suggested to accompany this chapter. A part or all of them may be included, according to convenience.

(1) Field observations of such cultural operations of the cotton crop as may be in progress. Written descriptions of the operation may be made, with particular reference to the following points:

(*a*) Efficiency of the operation.

(*b*) Amount of the operation performed by one man and team (single or double) in one day.

(*c*) Cost per acre of the operation.

(2) A visit to an operating ginnery, by which the students should gather a general knowledge of the ginning and baling processes.. A brief report may be made of the operations.

(3) Instruction by an expert at one or more special periods in sampling and grading cotton.

(4) A study of the appearance of plants attacked by the principal diseases mentioned in this chapter. A brief, descriptive report should be given.

QUESTIONS

1. How long a period between frosts required by cotton?
2. How is production affected by rainfall? By temperature?
3. Describe the climate of the cotton region.
4. How is the appearance of the cotton plant affected by different soils?
5. Describe the best cotton soils.
6. Compare value of rich soils in north and south portion of the cotton region.
7. Compare soil adaptation of upland and Sea Island cotton.
8. State the effect of fertilizers on cotton.
9. Compare the value of fertilizers on cotton and corn.
10. State the importance of phosphate. What form is preferred?
11. State the effect of nitrogen. Where used to best advantage?
12. How is nitrogen best supplied?
13. How important is potash?
14. How important is lime?
15. In a complete fertilizer what proportion of the elements is recommended?
16. What amount of fertilizer used? How is fertilizer best applied?
17. Describe the preparation of land for cotton as to (1) disposal of old stalks; (2) time of plowing; (3) method of plowing; (4) depth of plowing; (5) disking and harrowing.
18. Compare planting on ridges or beds, and planting on level land.
19. How important is early planting? How is planting usually accomplished?
20. What is best amount of seed to use?
21. How should the spacing of cotton plants be regulated on good and poor soils?
22. Describe the best methods of cotton cultivation.
23. How is the weeder used in cotton culture?
24. Describe a ginning outfit.
25. State points in grading cotton.
26. What are the grades?
27. Where is cotton mostly sold abroad? Where in the United States?
28. Describe the cotton boll-weevil and measures of control.
29. Describe the boll-worm and measures of control.
30. Describe the following diseases and measures of control: (1) Boll-rot, (2) cotton wilt, (3) cotton rust.
31. Principal uses of cotton.
32. Name the principal cotton country in last century. At present.

33. How does cotton rank in importance with other crops in the United States?
34. Name the most important cotton states.
35. Give the early history and origin of cotton.
36. Relate the history of cotton culture in the United States.
37. Was native cotton found in America?
38. What influence did the invention of Whitney and Arkwright have on the development of cotton culture?
39. When did cotton manufacture begin in the United States?
40. Give history of manufacture of cotton after introduction of the power loom.
41. How many species of cotton and where is each grown?
42. What species is grown in the United States?
43. Name the types of upland cotton.
44. Name and describe the principal types of short-staple cotton.
45. Where is Sea Island cotton grown, and how does it differ from upland cotton?
46. Describe the parts of a cotton plant in the following order: Appearance of plant; branches; leaves; flowers; squares; bolls.
47. What proportion by weight is fiber? Proportion of fiber to seeds?
48. Describe cotton fiber.
49. How can you distinguish between ripe and unripe cotton fibers?
50. Compare cotton and wool fibers.
51. Name the more important factors in judging the value of cotton.
52. What proportion of seed in lock-cotton?
53. State composition of seeds.
54. Are seeds smooth or fuzzy?
55. What products are derived from seeds?
56. How are oil and oil cake made?
57. Name the principal food and fertilizing constituents in cottonseed meal.
58. State value of cottonseed meal for feed; for fertilizer.
59. What use is made of cottonseed oil and hulls?

CHAPTER XXVIII

FLAX

FLAX is one of the oldest cultivated crops, since its value as a fiber plant was discovered very early by mankind.

The great use of flaxseed as a source of oil is largely a modern development, while the use of flax fiber has declined since the development of cotton culture.

Importance of the Crop.—At present most of the world's flax crop (Fig. 88) is grown for oil rather than fiber.

Production of Flax, 1907–1908–1909

Country	Flaxseed, bushels	Flax fiber, pounds
Argentine	39,042,000	
United States	25,504,000	
Russia	21,689,000	1,542,600,000
India	11,814,600	
Other countries	5,768,000	235,000,000
World	103,817,600	

In North America flax culture has largely followed the breaking up of new prairie lands, being especially adapted to grow on new sod lands. The three leading States for the years 1907–1908–1909 were:

North Dakota	13,867,000	bushels
South Dakota	5,441,600	bushels
Minnesota	4,668,000	bushels

These States produce about 90 per cent of the United States flax crop (Fig. 89). Flax culture is also developing rapidly in the new territory of Canada.

Description.—The Latin name of flax is *Linum*, from which we get our words line, linen, lint, and linseed. Botanists recognize 135 species of plants belonging to the flax family, but only one of these has been brought under cultivation as a farm crop, though several are cultivated as ornamentals.

The common flax has bright blue flowers, but there is also a white flowered sort, sometimes called Dutch flax. Flax is a slender branching plant, eighteen to thirty-six inches high, terminated by numerous "seed balls" (Fig. 90), each normally containing ten seeds.

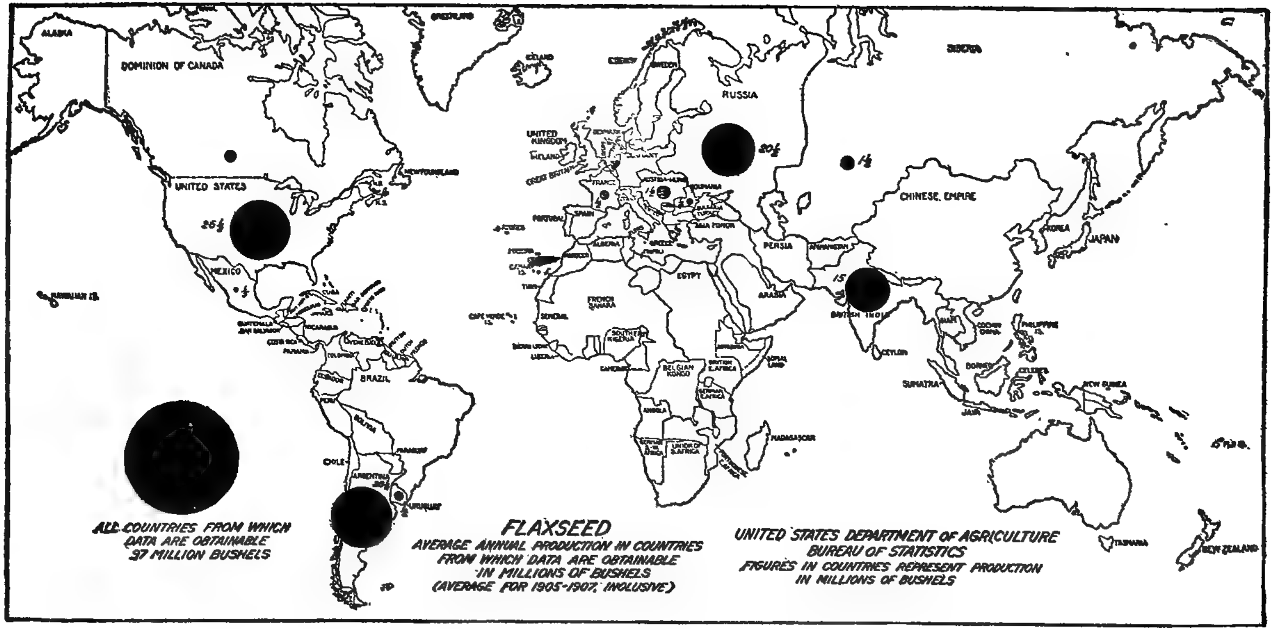


Fig. 88.—Production of flaxseed in the world.

Flaxseed is very rich in both protein and oil. After the oil is extracted a by-product is left known as oil cake, very rich in protein. Oil cake is highly prized as a rich stock feed. The following table shows an average analysis of flaxseed and oil cake, compared with a starchy grain like wheat:

Flaxseed and Linseed Cake Compared with Wheat

	Flaxseed, per cent	Linseed cake, per cent	Wheat grain, per cent
Water	9.1	10.1	10.5
Ash	4.3	5.8	1.8
Protein	*22.6*	*33.2*	11.9
Crude fiber	7.1	9.5	1.8
Nitrogen free extract	23.2	38.4	*71.9*
Fat (oil)	*33.7*	3.0	2.1

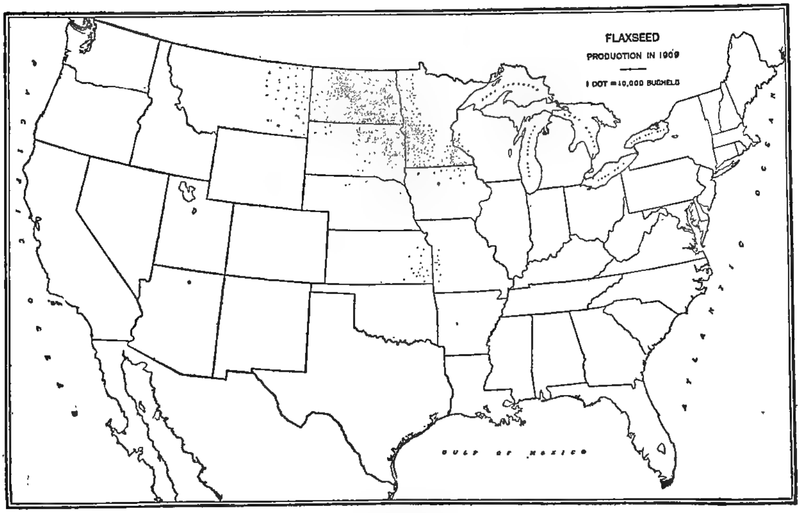


FIG. 89.—Distribution of flax production (seed) in United States. (From U. S. Census Report, 1910.)

The oil is extracted by grinding fine, heating to 160° F. and extracting by pressure (old process), or treating the meal in vats with naphtha (new process).

The fiber of flax comes from the stem. The stem is made up of three distinct parts: The outer, called bark; inside this a woody layer made up of bast fiber, and the inner part or pith.

The useful fiber comes from the bast layer. From twelve to fifteen per cent of the flax straw is recovered as pure fiber.

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Culture.—Flax will grow well in both dry and humid climates, but in general rather dry climates produce the best seed crops, while best fiber is grown in rather cool and humid climates, where conditions are favorable for a long growing season.

Flax requires rather rich productive soils, especially for fiber production.

Flax is least adapted of all the cereal crops to compete with weeds, as it is a slow growing, fine stemmed plant, with fine leaves, and shades the ground very little. This is one reason why it is grown

Fig. 90.—Flaxseed balls.

on newly broken prairie soils, as they are usually quite free from weeds the first year or two. Flax also does relatively better on raw new land than other crops, and its culture in general has followed the breaking up of the prairie lands. On old soils the principal consideration in preparing the land for flax is to free the soil from weeds.

Flax is sensitive to frost and should be sown when all danger is over. It is generally sown rather late, from the first to middle of June. For seed growing, flax is sown rather thin, or at the rate of

two to three pecks per acre. When sown thin it branches freely, the seed balls being mostly borne at the ends of little terminal branches.

For fiber it should be sown so thickly that all branching is prevented, producing only long straight stems. From five to ten pecks per acre are sown for fiber.

Harvesting.—Flax seldom all ripens uniformly and judgment must be used to harvest, when the highest percentage of seed balls are ripe at one time. Flax may be cut with a self-binder, but it is still common practice to leave it unbound in loose gavels. When cured it is threshed directly from the field or stacked.

For fiber the flax is pulled by hand for best grade of white fiber, as the cut ends are apt to become discolored. For extracting the fiber the straw is first allowed to rot, by lying in the field for several weeks or actually placing under water. This process is called "retting." The fiber, however, is not affected by the retting, and can be separated by breaking, beating, and combing out the decomposed material.

Diseases.—The most destructive disease of the flax plant is wilt. This is a parasitic disease attacking the stems, cutting off the natural water supply of the plant and causing it to wilt. The disease is carried over in old stems, seeds, and will also live in the soil for five or six years. Where wilt is prevalent flax should not be grown on the same ground oftener than once in six years. The seed should be carefully fanned to remove diseased seeds, and treated with formalin solution to kill adhering spores. One pound formalin to forty gallons of water is the recommended strength.

QUESTIONS

1. What are the principal uses of flax?
2. Where most extensively grown (*a*) for seed; (*b*) for fiber?
3. Name the leading States in flax production.
4. Describe a cultivated flax plant.
5. In composition compare with wheat.
6. How is the oil extracted?
7. What is the oil cake used for?
8. Describe structure of a flax stem.
9. What per cent is pure fiber?
10. Give the best conditions for growing seed; fiber.
11. Why is flax often grown on new prairie land?
12. Compare the culture of flax for seed purposes and when grown for fiber.
13. Describe harvesting flax for seed; for fiber.
14. How is fiber separated?
15. How is flax wilt controlled?

CHAPTER XXIX

SORGHUMS

Sorghum, like the corn plant, is of tropical origin, its original home apparently being central or northern Africa. There is also some evidence that some types may also have had an independent origin in India. From these tropical regions its culture has spread into temperate zones, until we find it cultivated extensively in Manchuria in a latitude of 40° north and in the south temperate zone in the very southern part of Africa.

Where Sorghums Are Produced.—We have very little published data on sorghum as a world crop, but it is known to be extensively cultivated through all North Africa, where it probably ranks as the leading grain crop. It is also grown extensively as a grain crop in South Africa. In India sorghum is also a very important grain crop, and is stated by some authors as the principal grain food of the poor. Sorghum probably ranks next to rice as a grain crop in India. It is cultivated to some extent throughout China, and in certain parts of North China and Manchuria is an important grain crop. Its culture is not important in Europe.

In the United States sorghum is grown for syrup making, as a forage plant, and as a grain crop. It will be noted that in Africa and Asia sorghum is grown principally as a grain crop.

As a *syrup* crop sorghum is grown largely in the East Central States, or rather the belt of States from Missouri to North Carolina and south of the Ohio River. Tennessee is the leading State in syrup production.

As a *grain* and *forage* crop sorghum is grown principally in the belt of States lying east of the Rocky Mountains, and from the Nebraska-Dakota line south through Texas. As a grain crop sorghum is grown principally in the western part of these States, while it is grown for forage through the whole area.

Broom corn is also a sorghum. About two-thirds of the broom corn is grown in Illinois, and about all the rest in Nebraska, Kansas, Missouri, and Oklahoma.

The Acreage.—The acreage, as nearly as can be estimated from the Census of 1909,[1] is as follows:

Acreage of Sorghums

	1909	1899	Increase per cent
Grain sorghums	1,635,153	266,513	513.5
Sorghums for forage (including both grain and sweet sorghums)	1,900,000		
Sorghum for syrup	370,000	244,000	51.0
Broom corn	326,102	178,584	82.6

Three-fourths of all the sorghum for grain and forage is grown in the three States of Texas, Kansas, and Oklahoma, in the order named. The approximate acreage for grain and forage in the three States is as follows:

Acreage of Sorghums in Three Leading States

State	Grain sorghum acreage	Forage sorghum acreage
Kansas	388,495	531,000
Oklahoma	532,515	301,000[2]
Texas	573,384	655,000[2]

Classification of Sorghums.—Sorghums are generally classed into two groups:

1. Saccharine sorghums or sweet sorghums (Fig. 91). These sorghums all have sweet, juicy stems and are grown for syrup making or for forage.

2. Non-saccharine sorghums (Figs. 92 and 93). This group has a rather dry pith and very little sugar in the juice. These sorghums are sometimes called the grain sorghums, and are sometimes divided into three types as follows:

(*a*) Kafir: Heads compact, erect.

(*b*) Durra: Heads compact, pendent.

(*c*) Broom corn type: Heads loose, spreading (Fig. 94).

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[1] Estimated from 1909 Census. Separate figures are not given, as sorghum is classed with "coarse forage," which class also includes corn fodder. However, statistics from the Kansas State Board of Agriculture show 631,000 acres of sorghum forage out of a total of 653,000 acres of coarse forage. In the five States growing sorghum as coarse forage (Nebraska, Kansas, Oklahoma, Texas, New Mexico) there is about 2,000,000 acres of coarse forage, and estimating 95 per cent to be sorghum gives above figures.

[2] Estimated, see footnote to above table.

Kafir or Kafir Corn.—The Kafir corns were introduced into the United States mostly from South Africa, where they have long been

FIG. 91.—Head of amber sweet sorghum. (U. S. Department of Agriculture.)

cultivated. They grow to an average height of five or six feet and have an erect, very compact head. The three principal varieties are

distinguished by the color of seeds, and are known as White, Red, and Blackhull Kafir corns (Fig. 94). Of the three varieties the Blackhull is most popular and the Red Kafir is next. The White varieties have never been cultivated extensively, as the heads do not always come out of the leaf sheath and are likely to rot. One fault of the Red Kafir is the astringent taste of the seed-coat, a quality found in all colored sorghum seeds, but not found in white seeds.

Fig. 92.

Fig. 93.

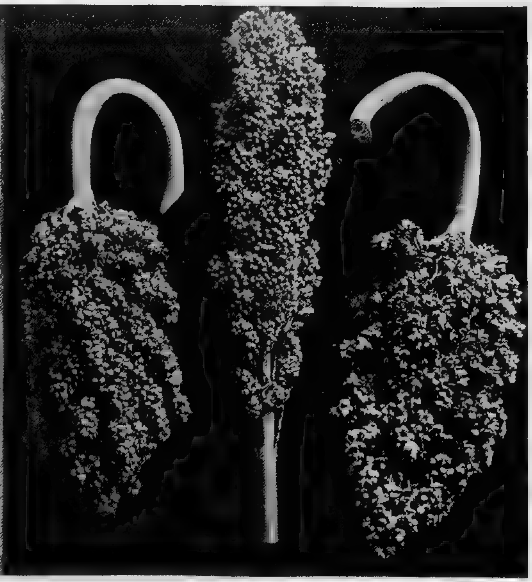

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Fig. 92.—Plant of Kafir corn.
Fig. 93.—Non-saccharine sorghums. (1) Milo maize, (2) Blackhull White Kafir corn, (3) Brown Durra corn.

Durra.—The heads of this group of sorghums are generally bent over or "goosenecked," and the seeds are large and flat. The Durra corns were apparently introduced from North Africa, where they are the prevailing types as the Kafirs are in South Africa.

The principal types of Durra are the White (Fig. 94, *B*), Brown, and Blackhull; also Yellow Milo or "Milo Maize." Feterita is a type with *erect* heads, white seeds, and black hulls. Other names for Durras are "Jerusalem corn," and "Egyptian rice corn."

Of the above types, Yellow Milo is by far the most popular.

Being earlier it is grown farther north than other Kafirs or Durras. Certain dwarf strains have been developed which are not only very early but, as a grain crop, are easier handled in harvesting. Feterita, a recent introduction, promises to be equal or superior to Milo, and is rapidly gaining in favor. The Durras, as a class, are better grain producers than the Kafirs, but are not so good as forage crops.

Broom Corn Group.—This group includes rather tall-growing sorghums (six to ten feet) with branching heads (Fig. 95). They

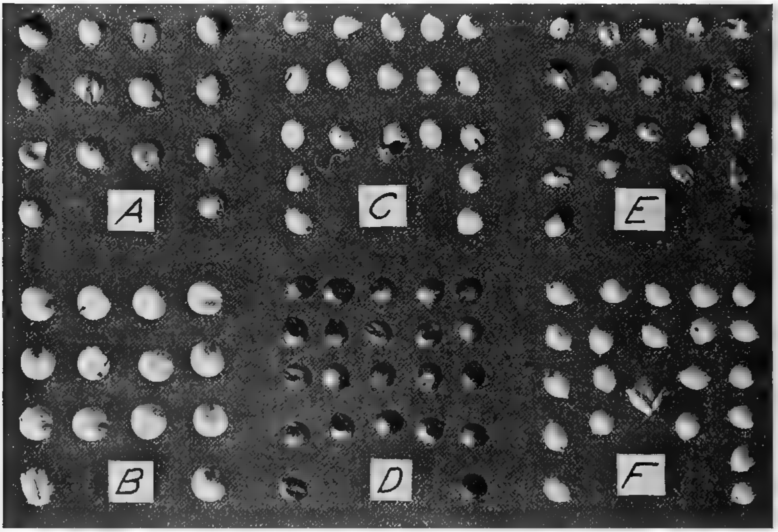

Fig. 94.—Sorghum seeds: *A*, Milo; *B*, White Durra; *C*, Blackhull Kafir; *D*, Red Kafir; *E*, Brown Kowliang; *F*, Shallu. (U. S. Department of Agriculture.)

have been introduced from Asia: the Shallu from India and the Kowliang from China and Manchuria.

The two above-mentioned varieties are grown as grain sorghums, but their introduction is recent and they have not yet come into extensive cultivation. They are said to be very drought resistant, and the Kowliang is adapted to culture farther north than most grain sorghums.

Broom corn, from which brooms are manufactured, is a form of this sorghum, with very long branching heads.

Climate for Sorghums.—Sorghums, being of tropical origin, flourish in hot, sunshiny climates. One of the most striking char-

FIG. 95.—Broom corn group of sorghums. (1) broom corn, (2) Kowliang, (3) Shallu.

acteristics of sorghums is their great drought resistance and resistance to other climatic conditions that generally prevail in semi-arid

regions, as intense sunshine, dry air, and hot winds. Certain varieties, especially the sweet sorghums, flourish in regions of heavy rainfall, but even these are quite drought resistant. The Kafirs and Durras, however, probably reach their best development under only moderate rainfall (ten to twelve inches for the growing season) and are very resistant to dry, hot climates.

How Sorghums Resist Drought.—Actual test has shown sorghums to require less water than many other crops. This is determined by growing plants in large cans and keeping a record of the water used. The water used is generally expressed in the number of pounds required to produce one pound of dry weight. With some of the common crops, the following data have been secured by Briggs and Shantz at Akron, Colorado. (Bureau of Plant Industry Bulletin 284.)

Water Requirements of Grains

Crop	Pounds of water to produce one pound of dry weight	Percentage compared with wheat
Oats	614	122
Barley	539	106
Wheat	507	100
Corn	369	73
Sorghum	306	60
Millet	275	54

While sorghum requires less water than the small grains, it is not very different from corn. Yet sorghum is more drought resistant than corn, which leads to the conclusion that it must also have other qualities to consider. It appears to be helped by its ability to remain alive, but without growing, through long periods of drought, apparently without injury, and at once recover and grow rapidly when rains come. If sorghum, at any stage of growth, is subjected to long, severe drought, the outer leaves roll up about the plant, protecting the younger leaves and growing top. It may remain in this state for weeks, with little or no growth, and quickly recover and continue growth when rains come. On the other hand, corn, if submitted to such a drought, would in a short time be killed or, at least, be severely injured. In fact, it is said that any check to the corn plant during its growth will cause permanent injury. This is generally true of all crops, but sorghums suffer least of all.

Soils for Sorghums.—Sorghums do well on any productive soil (Fig. 96). They are also more alkali resistant than the grain crops and are regarded as a crop that can be grown in soils comparatively high in alkali salts. Sorghums are vigorous growers, and often a profitable crop, especially for forage, can be raised on land too exhausted for good crops of small grain or corn.

Effect of Sorghums on Land.—Farmers usually regard sorghum as "hard on the land." This is probably due to the thorough search the sorghum roots make for available plant-food, leaving the soil more thoroughly exhausted. However, the total plant-food re-

Fig. 96.—Field of selected Brown Kowliang.

moved is no larger than in the case of an equal tonnage of other crops, and usually the second year after sorghum, no injurious effect is noticed.

Cultural Methods.—Sorghum is grown for four purposes: (1) grain; (2) forage; (3) syrup; (4) broom brush.

For grain, syrup, and broom brush it is always grown in rows about like field corn, except that two to three times as many plants are grown per acre. The rows are about the same distance apart (forty to forty-four inches) as corn, but the plants four to ten inches in the row instead of twelve to twenty inches.

For forage, sorghum is either grown in wide rows, as mentioned, with the plants very thickly in the row, or it is sown broadcast or is drilled thickly with a grain drill.

Rate of Seeding.—Four to six pounds of seed per acre is sufficient to give a good stand in rows forty-two inches apart. Ordinarily the plants are spaced about four to six inches in the row, but in very dry regions ten inches apart is often preferred. The amount of seed is also regulated by size, as the seeds of the Durra group are about twice the size of sweet sorghum or broom corn.

Time of Seeding.—Sorghum is more tender than corn and is usually planted after corn-planting. Planting is often deferred, however, until quite late, just so it has time to mature before frost. However, in the southern States an insect known as the sorghum midge attacks late-sown sorghum, destroying the seed, and very early planting is desirable whenever the midge is present.

Planting and Cultivation.—The same tools are used in planting and cultivating as for corn. Special plates for sorghum seed are used in the planter. In cultivation, more care is required the first time over as the plants are small and slow in growth for the first few weeks.

Harvesting Grain Sorghums.—Grain sorghums are harvested in three ways: (1) with the corn binder; (2) when dwarf varieties are grown, the grain binder may be used; (3) the heads may be cut off by hand. In the latter case the heads from several rows may be thrown together on the ground to cure, or a wagon may be driven alongside and the heads thrown as cut directly into the wagon-box. When the heads are well cured the sorghum is threshed in an ordinary grain thresher.

Yield of Grain Sorghums.—The average yield of grain sorghums varies from twelve to twenty bushels per acre. Forty bushels per acre is considered a good crop, while crops of seventy bushels are occasionally reported.

As compared with Indian corn, grain sorghum will not yield as well in regions having twenty-five to thirty inches annual rainfall, but in drier regions grain sorghum will make a fair crop when corn is a complete failure. The region of grain sorghum culture therefore lies just outside of the corn belt.

Feeding Value of Grain Sorghums.—Kafir and Milo grain are somewhat more starchy than other cereals, and require more protein feed to balance them. Also they have a higher per cent of hull and are a little less digestible. Ordinarily for stock feed it is estimated that 100 pounds of sorghum grain equals about 80 to 90 pounds of corn. For poultry feed, however, sorghum grain is considered superior to corn, and is often used in large proportion in poultry feeds.

Owing to the heavy hull, sorghum seed should be ground for live stock, but may be fed whole to poultry.

Sorghum for Forage.—For forage the sweet sorghums are preferred. The stems contain considerable sugar and cattle will usually eat the stems as well as the leaves. The stems of grain sorghum are not only more pithy and tougher, but the plant is less leafy. However, grain sorghums are used extensively as fodder, when the heavier grain crop is considered to offset the less valuable fodder.

For forage, the sorghum is either (1) sown thickly in rows three to four feet apart and cut with the corn binder or (2) sown broadcast by hand or with the grain drill, to be cut with a mower and cured as hay.

Rate of Sowing.—Sorghum is sown broadcast at the rate of one to three bushels per acre. It should be sown thick enough to keep the stems down to small size. On poor soils or in dry regions the thinner seeding is practised, while on rich soils in humid regions two to three bushels per acre are sown.

Sorghum for Soiling.—There is no crop better for cutting green for feeding live stock. It is good feed from the time it is four feet high until frost comes. A second crop immediately sprouts up from the stubble, thus giving two crops in the South. Sorghum also makes excellent silage.

Sorghum for Syrup.—Sweet sorghum was first grown in America for syrup making. It was introduced from France about 1853 under the name "Chinese sorgo," but the variety was what we now know as Amber sorghum.

For syrup, sorghum is grown in rows. When the seed is in the dough stage the leaves are stripped off. The canes are then topped and cut. The juice is extracted on roller presses, clarified and evaporated. Sorghum varies greatly in quality, but usually a ton

of canes will yield from ten to thirty gallons of syrup. Three tons of canes per acre is a fair yield.

Broom Corn Culture.—Broom corn grows eight to ten feet tall, has a dry pithy stem, and very long branching heads of "brush." It has been cultivated in Europe for at least 300 years, and in America since 1800.

Where Cultivated.—Illinois produces about two-thirds of the broom-corn crop, and the rest is grown principally in Missouri, Kansas, and Oklahoma.

Varieties.—There are two general types: (1) standard, growing ten to twelve feet high, with a brush eighteen to twenty-four inches long; (2) dwarf broom corn, growing four to six feet high, with a brush twelve to eighteen inches long.

Culture.—Any good corn land will grow broom corn, but it is considered important to have the land quite uniform in order to produce a crop that will ripen at the same time and will be of uniform quality.

It is grown in rows three to three and one-half feet apart, with the plants two to three inches apart in the row.

When just past full bloom, the heads are harvested and cured. Considerable skill is required in harvesting and curing to secure a good quality.

QUESTIONS

1. Where did sorghum originate?
2. How important a crop is sorghum in the Old World?
3. What are the principal uses for the sorghum crop?
4. Where in the United States is it grown for syrup; grain forage; broom corn?
5. Give the relative importance of these crops.
6. Name the principal groups and types of sorghum.
7. Distinguish between Kafir and Durra.
8. What is the principal use of the saccharine sorghums? The non-saccharine sorghums?
9. Define the climatic requirements of sorghum.
10. What explanations for the great drought resistance of sorghums?
11. Discuss the range of soil conditions that will grow sorghum.
12. Is sorghum "hard on land"?
13. Describe the method of growing sorghums in rows.
14. How are grain sorghums harvested?
15. Give the yield of grain sorghums compared with corn.
16. Define the feeding value of sorghum grain.
17. What kind of sorghum is preferred for forage?
18. Describe method of culture.
19. How much syrup can be made from an acre of sorghum?
20. Describe the culture of broom corn.

CHAPTER XXX

IRISH POTATOES

As human food in the world, wheat undoubtedly ranks first, but potatoes probably rank second. In Europe among the poorer classes they rank first. This is due to their easy and cheap production and nutritious property.

Where Potatoes Are Grown.—The relative ranking of potatoes and other crops in the world and the United States for the years 1906–1910 is shown by the following tables:

World's crops in millions of tons, 1906–1910	
Potatoes	156
Corn	113
Wheat	107
Oats	67
Rice	67
Rye	46
Barley	33

Relative value of crops in United States in millions of dollars, 1906–1910	
Corn	1,431
Hay	681
Cotton	570
Wheat	590
Oats	367
Potatoes	187
Barley	92
Tobacco	82

Over ninety per cent of the world's potato crop is grown in Europe (Fig. 97), where they are the chief food of poor people, and are also used for stock feed and in the arts.

Yield of Potatoes by Continents (1905–1909)

Continent	Millions of bushels	Per cent of crop
Europe	4,745.7	91.2
North America	378.7	7.2
Asia	38.2	.7
Australia	19.4	.4
South America	16.8	.4
Africa	4.8	.1
	5,203.6	100.0

Germany and Russia produce more than one-half the world's potato crop. The production and yield per acre of principal countries are as follows:

Country	Millions of bushels, 1905-1909	Average yield per acre, 1900-1909
Germany	1,689	200.0
Russia	1,048	99.9
Austria-Hungary	709	134.9
France	529	133.8
United States	304	92.0

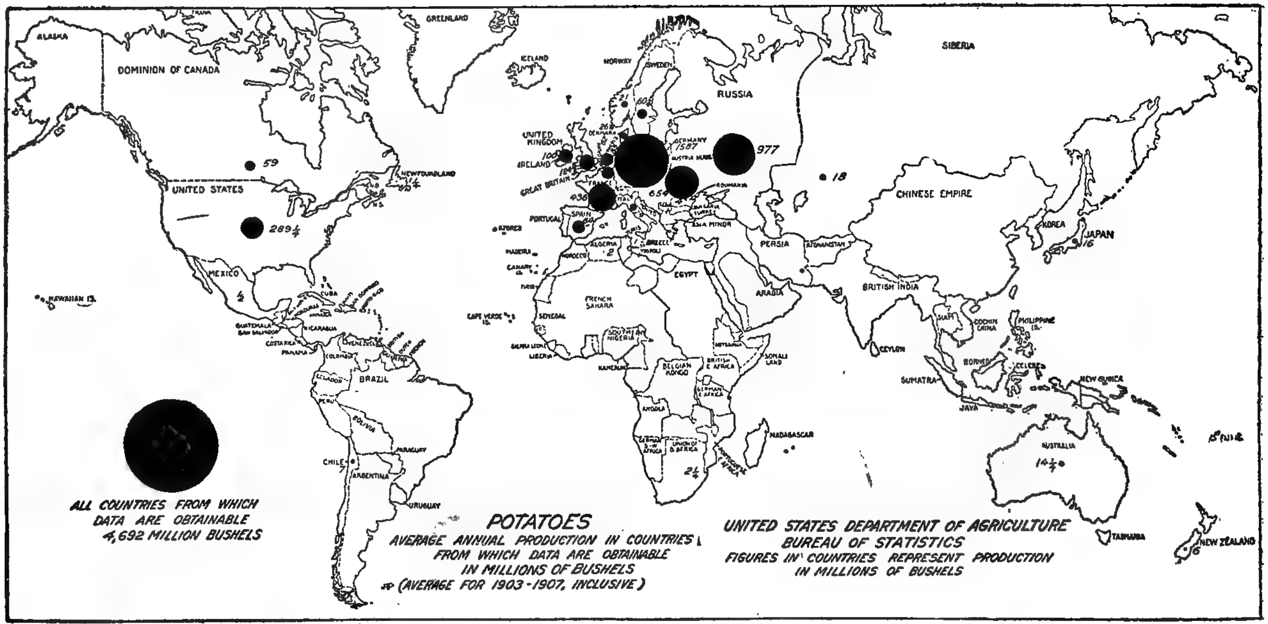

FIG. 97.—Chart showing distribution of potato production in the world.

In the United States, New York has led in potato production for the past quarter century (Fig. 98).

The leading States and yield per acre are as follows:

State	Production in millions of bushels, 1906–1910	Yield per acre, 1900–1909
New York	43.5	88
Michigan	30.0	88
Pennsylvania	23.6	82
Wisconsin	23.5	92
Maine	22.8	180

In the last few years Michigan, Wisconsin, Maine, and Minnesota have been rapidly gaining in production and are now all close rivals of New York.

Origin and History of Potatoes.—Several wild varieties of potatoes are found growing throughout the Andes Mountains in South America, and continuing northward through the mountains of Mexico and into southwest Colorado. South American natives have apparently cultivated the potato for many hundreds of years.

Early explorers took potatoes back to Europe, but they did not become an important food plant there until about the year 1750. Its extensive culture developed first in Ireland, from which it got the name "Irish Potato," where it was introduced about 1584, probably from seed sent back by Sir Walter Raleigh's expedition to America.

Description of the Plant.—Potatoes are closely related botanically to several other important plants, as tobacco, the tomato, and egg-plant. Wild potatoes bear only small tubers of poor quality, but these have been improved by selection and cultivation.

Potato Seeds.—While potatoes frequently blossom under cultivation, they seldom bear seeds. This appears to be due to the pollen having lost its ability to fertilize under cultivation. The seed balls are borne on the tips of vines and resemble small green tomatoes, each containing about 300 seeds (Fig. 99). If the seeds are planted, they produce small tuber-bearing plants. If the tubers are planted, a second year a plant of normal size is grown. While most of the varieties grown from seed are of little value, yet occasionally varieties of great value are originated in this way.

The Potato Tuber.—The potato tuber is not a root, but corre-

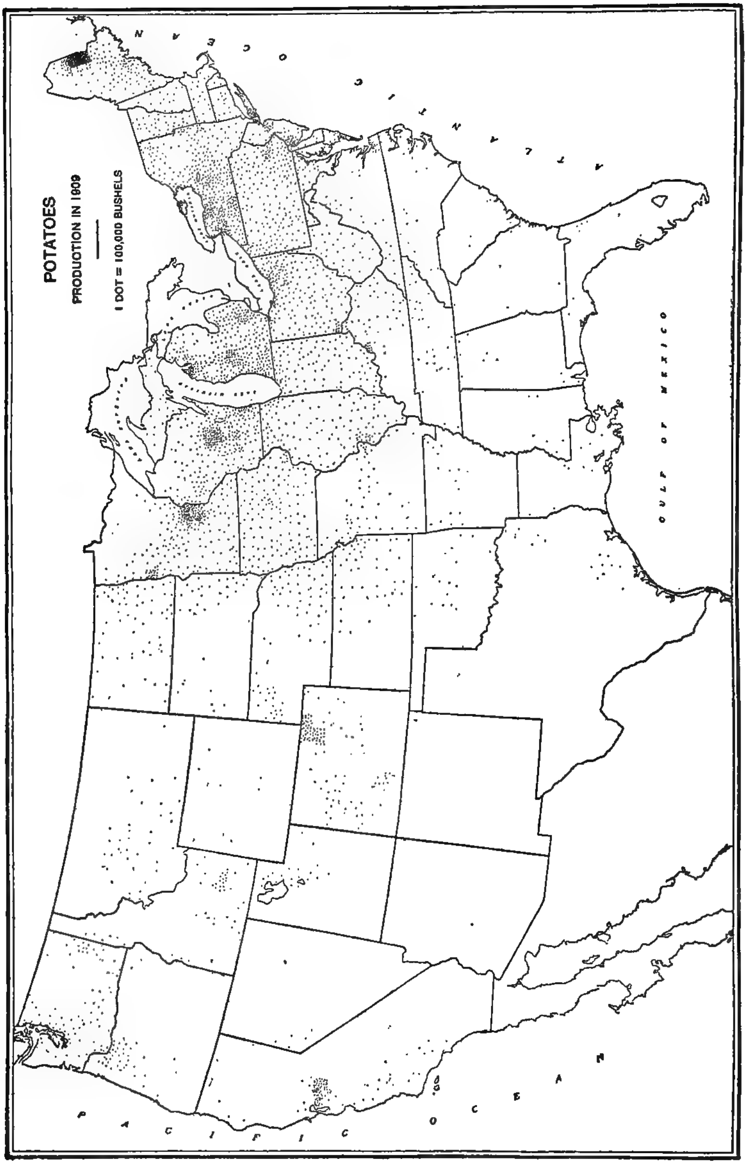

FIG. 98.—Chart showing the distribution of potato production in the United States. (From United States Census, 1910.)

sponds to an underground branch of the stem that has become thickened (Fig. 100).

The eyes of the potato correspond to latent buds on the stem, while the inner portion corresponds to the structural parts of the stem. The sweet potato differs from the Irish potato in being an enlarged root, not a stem.

Classification of Potatoes.—At least 400 to 500 varieties of potatoes are known in America, while the total in the world is of course much larger. New varieties are each year put on the market. However, many varieties are so similar that for all practical purposes there is no difference, and in many cases old established varieties have simply been given new names.

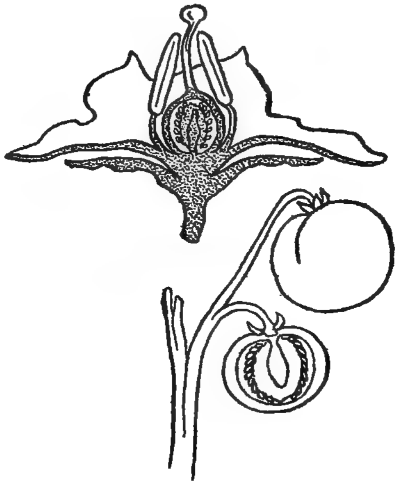

FIG. 99.—Drawing in diagram of potato flower, and mature seed balls (flower enlarged). They are almost identical with the flowers and fruits of the tomato, showing the close relation of the two plants.

The classification of American potatoes has been studied by Mr. William Stuart, of the United States Department of Agriculture. He divides them into eleven natural groups which can be fairly easily distinguished. The principal features he uses in classifying are the shape and color of tuber, the color of sprouts, and color of flowers.

Shape of Tuber.—Many descriptive terms are necessary to describe potato tubers, as they are so variable.

Round, oblong, and *long* refer to relative length. Any of the types may be *flattened* or *round.* Flat types are also described as *broad* or *narrow. Spindle shape* refers to tubers tapering at one end, as contrasted with *uniform.*

Color of Skin.—Color of tuber is described as *white, cream-white, flesh color, pink, rose, red* and *bluish, mottled,* and *russet brown.*

The skin may also be *smooth,* marked with *russet dots,* or russet. There are also degrees of smoothness, some varieties being *glistening* smooth, while others are *dull.* The degree of russeting also varies.

Sprouts.—The color of sprouts is very important in determining the main groups of varieties. The color is determined by germinating the potatoes in the dark, and as soon as the sprouts appear,

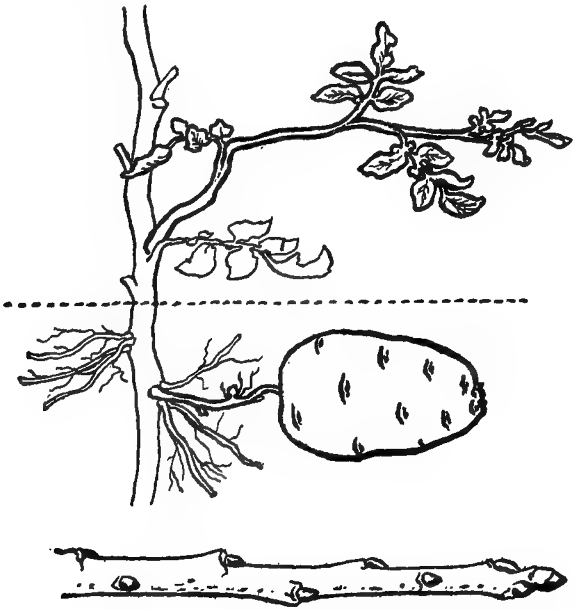

FIG. 100.—Illustration of a potato plant showing relation of the above-ground stem and underground stem. The end of the underground stem is enlarged into a tuber. The eyes correspond to buds, and are arranged in a spiral about the tuber. Below is a peach twig to illustrate farther the relation of tuber and a stem.

examining for color, usually with a magnifying glass. The sprout is tipped with minute scales or leaflets, which may be either colored or white. Also base of sprouts may be either colored or white.

The usual colors are *white, cream-white, pink, rose, rose-lilac, magenta, lilac, violet, deep violet.*

Flowers.—Colors are *white, rose, rose-lilac, rose-purple, purple* and *violet.*

The Principal Groups.—Stuart[1] divides potatoes into the following principal groups:

1. Cobbler: Roundish; creamy white (Fig. 101).

2. Triumph: Roundish; creamy white to red.

3. Early Michigan: Oblong or long-flattened; white or creamy white.

4. Rose: Roundish, elongated-flattened or spindle-shape; flesh-colored or pink (Fig. 103).

Fig. 101.

Fig. 102.

Fig. 101.—Variety, Irish cobbler, representing the early, round, white-skinned type.
Fig. 102.—Rural New Yorker, representing the oval-flattened type, of white-skinned potatoes with blue sprouts. Above specimen is ideal market shape (¾ natural size).

5. Early Ohio: Round, oblong or ovoid; flesh-colored to light pink, with russet dots.

6. Hebron: Elongated, sometimes flattened; creamy white, often mottled with pink.

7. Burbank: Long; white, or creamy; also both smooth and russet varieties.

8. Green Mountain: Oblong, broad, flattened; dull creamy or light russet.

[1] Stuart, William: United States Department of Agriculture, Bulletin 176.

9. Rural: Round-flattened to short oblong; creamy white or deep russet (Fig. 102).

10. Pearl: Round-flattened; dull white, russet or bluish.

11. Peachblow: Round or round-flattened; creamy white splashed with pink, or pink.

The first six groups are largely early varieties, while the last five groups are mostly late varieties.

Importance of the Groups.—The Rose group probably contains the largest number of varieties, and is one of the oldest (Fig. 103). They are not, however, cultivated so extensively as several other

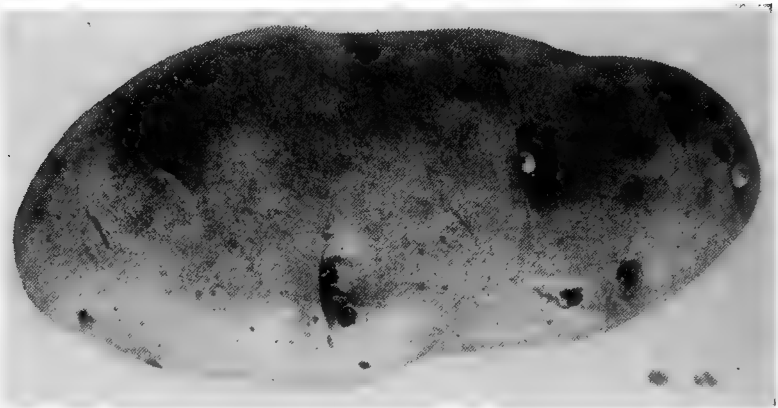

FIG. 103.—Early Rose, representing the Rose group of long, pink or red-skinned potatoes with rather deep eyes.

groups. They are mostly very early and pink colored, and are popular in the South Atlantic region where this type is grown, to ship as "new potatoes" for the northern market.

In the Northeastern States, Irish Cobbler (Fig. 101) is the most important early potato along the Atlantic Coast, where most of the early crop is grown. They are very productive for early potatoes.

For early garden crop the Triumph group of varieties are preferred as to quality, but are less productive.

For late or main crop the Rural group leads (Fig. 102), with the Green Mountain type as second. In general the Green Mountain group requires a cooler summer, and sandier soil than the Rural

group of potatoes, and is therefore grown toward the North, at higher elevations and along the Atlantic Coast, while Rurals are grown on the heavier clay lands and at lower elevations, as Western New York.

In Southeastern States.—Here early varieties are most extensively grown for Northern markets. For shipping green, the colored potatoes are usually preferred to white, and here varieties of the Rose group are extensively used, also both Triumph and Cobbler.

North Central States.—In the northern part of this region, the

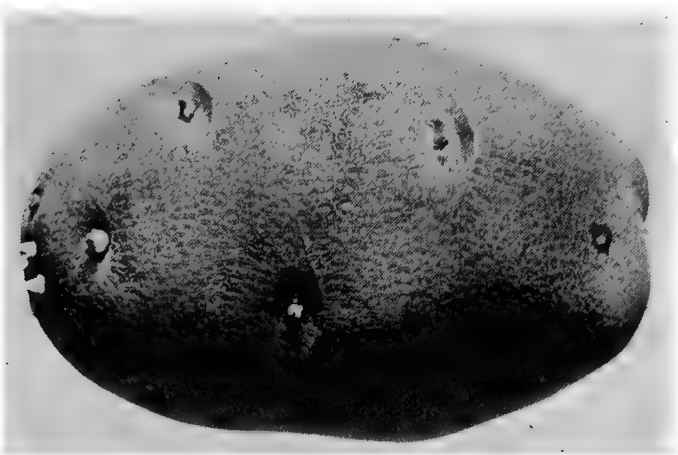

Fig. 104.—Russet Burbank, representing the medium long types of the Burbank group. Most Burbanks have a smooth skin, but this is a russet type (¾ natural size).

Rural and Burbank (Fig. 104) groups both give good results, but through the corn belt, early Ohio type is most important, though many varieties are grown to some extent.

Western States.—In Colorado the Rural, Pearl, and Burbanks are the principal groups, while the same three groups are also most important in the inter-mountain basin and on the Pacific Coast, though locally, one variety or another usually leads.

Market Types.—It will be noted that the principal commercial potatoes are either roundish, as in the Irish Cobbler, or oval-flattened, as Rural or Green Mountain; oblong, as in Rose group, or long, as

in the Burbank group. The general market preference now is for the oval-flat, Rural type, and medium in size.

Depth of and Number of Eyes.—This is also important, as deep eyes cause waste in peeling and injure the appearance. Both Green Mountain and Rurals have few eyes, and very shallow, which is one reason for their great popularity as market potatoes.

Color of skin adds more to appearance than quality. White or cream-white is preferred. For shipping green, the red or pink colored potatoes show the effects of bruising less, and are often grown in the South where "green" potatoes are shipped a long distance.

Structure and Composition.—The potato tuber may be divided into four principal parts (Fig. 105), namely:

Skin	2.5 per cent
Cortical layer	8.5 per cent
Outer medullary } Inner medullary }	89.0 per cent

The cortical layer and the outer medullary are both rich in starch and constitute 80 to 90 per cent of the potato. The inner medullary, sometimes called the core, is quite watery, and spreads irregularly from the center.

It is generally considered a mark of poor quality if the inner medullary is large and conspicuous.

In composition potatoes contain from 75 to 80 per cent of water, from 16 to 20 per cent starch, 2 to 3 per cent of protein and 1 per cent ash and a trace of fat and fiber. The dry matter of potatoes is very similar in composition to the dry matter of wheat.

In peeling potatoes, from 10 to 30 per cent is removed in the peeling, depending on the size of the potato and depth of the eyes. The loss is least with large, smooth potatoes.

CLIMATE AND SOILS FOR POTATOES

Climate.—Potatoes require a moist and cool climate. Climate is probably a much greater factor in potato production than soils, as they appear to grow well on any productive soils in a favorable climate.

It is well known that the cold summer climate of Scotland is almost ideal for potatoes. Crops of 300 to 500 bushels per acre are

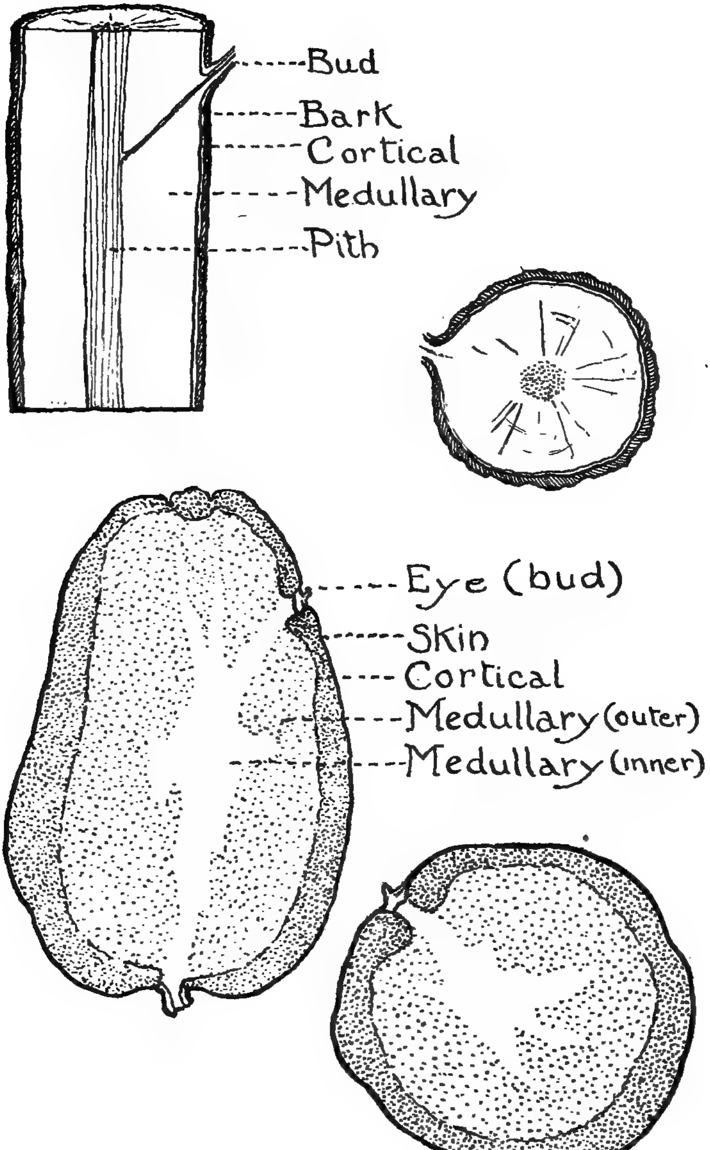

FIG. 105.—Illustration showing the internal structure of a potato tuber, and relation to structure of a stem. Note that the inner medullary, corresponding to the pith in a stem, is connected with the eyes of the tuber. The outer portion is richest in starch and the inner portion poorest in starch.

easily grown in Scotland. The warmer climate of England is less favorable.

In Europe great potato crops are grown in the cool summers of North Germany, the Netherlands, and Scandinavia, while the production is much less in South Europe or the hot summer climates of the interior of Hungaria or Russia.

In the United States the most favorable summer climate is found in the northern tier of States, especially Maine, which is noted for its large acre yield. High elevation has the same effect as northern climate, and we find ideal summer climate in Colorado, and north through the Rocky Mountains, and in the northwestern Pacific States. Farther south or in regions with hot, dry summers, it is necessary to handle the crop so as to avoid the summer heat. This is accomplished in the South by planting in midwinter, so the crop is made before dry summer heat. Sometimes they are also planted in midsummer, but make their principal growth in the cooler weather of fall.

Degeneration.—It has long been known that potatoes continuously grown in regions of hot summers will rapidly degenerate and become unproductive. In the South they find it necessary to buy seed potatoes from the North every year. Maine has long been a great seed-growing center, because of the favorable climate. Also New York State, Michigan, Wisconsin, and the Red River Valley produce good quality of seed. Good seed is also produced at high elevations farther south.

At the Nebraska Experiment Station [2] a very interesting experiment was tried. By mulching the potato ground with six inches of straw it was possible to not only keep the soil moist, but several degrees cooler than under ordinary culture. Above the straw, however, the tops were exposed to even greater heat than ordinary. It was found that the potatoes grown under straw retained their productiveness for years, while the same potatoes under ordinary culture rapidly degenerated. Even degenerate potatoes could be restored to strong vitality and productiveness by growing under straw for one year. This experiment is believed to demonstrate the importance of a cool, moist soil for growing seed potatoes.

[2] Annual Report, 1912.

Soils for Potatoes.—While potatoes are often grown successfully on heavy soils, it is generally recognized that loose, gravelly or sandy soils are best. Advantages claimed for loose soils are that (1) the crop is easier to plant, cultivate and dig; (2) the potatoes are smoother and of better quality; (3) fertilizer and manure are more effective; (4) potatoes are less affected by diseases; (5) crop is quicker in maturing.

New soils are also recognized as excellent, not only because rich in organic matter, but also free from diseases that affect potatoes. A rich clover sod is ideal, and it is generally arranged, where potatoes are grown in rotation, to put them on the sod land.

Manures and Fertilizers.—Fertilizer and manure is used in larger quantity on the potato crop than any other farm crop in the eastern States, as they are an intensive crop and give larger returns. In the gravelly potato soils of Maine, and the sandy soils of Long Island and the Atlantic Coast, potatoes are a leading crop, and commercial fertilizer is customarily applied at the rate of 1000 to 2000 pounds per acre each year. In general the soils in these districts are low in organic matter, not much barnyard manure is available and it is not the general practice to rotate with clover or grass to restore organic matter. The land is in potatoes at least one-half the time.

Farther back from the coast in Pennsylvania, Ohio, and New York, where potatoes are grown on the land only once in 4 or 5 years in rotation with other crops, the use of fertilizer is much less. On most of these farms, farmyard manure is available and it is customary to apply it on sod land to be broken for potatoes. Many such farms do not use fertilizer or only in light dressings of 300 to 800 pounds applied at time of planting. Surveys show that about one-half the farmers of this region use fertilizers and then seldom above 800 pounds per acre.

In the Middle and Western States, fertilizers are used in the more intensive potato growing districts, but most of the crop in these States is still grown on new land or in rotation, where little fertilizer is required.

Kinds of Fertilizer Used.—As pointed out heretofore in the text, grasses require fertilizers rich in nitrogen to stimulate vegeta-

tive growth, grains usually responding best to phosphatic fertilizers, while potatoes, in common with root crops, respond well to potash.

In general, potato fertilizers are low in nitrogen and high in phosphate and potash, the relative proportion usually being about 3–8–10 for the different elements. This is a typical fertilizer extensively used on the sandy soils of the Atlantic Coast, sandy soils being very deficient in potash. It is generally believed now, however, that the proportion of potash is higher than necessary.

In the interior where potatoes are generally grown on heavier soils and in rotation, the standard fertilizer, as above, is generally used in smaller quantity, though experiments indicate that phosphate is most important. Clay soils are usually well supplied with potash which is made available by decaying organic matter. If clover is grown in the rotation or farmyard manure is used for the potato crop, there is not much need of adding nitrogen except to help early spring growth. For such conditions, a fertilizer containing the elements in the proportion of 3–10–6 will probably be about right. However, experimenting is needed on each soil to determine the most profitable fertilizer to use.

Lime.—Much of the land where potatoes are grown is quite deficient in lime. On such soils lime will frequently give very much increased yields. On the other hand, lime also makes favorable conditions for certain diseases of the tuber, especially potato scab. Where potatoes are grown continuously, as on the Atlantic Coast, the scab soon becomes so bad on limed soils as to cause great injury. For this reason few of the growers are willing to use lime. In fact, it is due to the acid soils of the Atlantic Coast that such smooth, clean potatoes, free from disease, can be produced year after year.

Where potatoes are grown in rotation not oftener than once in four years, there is not much danger from scab if clean seed is planted. It is often necessary to use lime in order to grow clover and grass and there is little danger of undue potato scab if the lime is applied only once in four years and then at least two or three years before the potato crop.

Rotations.—Where potatoes are grown as a regular farm crop, it is customary to grow the potatoes after sod. No place is better

than a good clover sod, as clover not only leaves a good supply of nitrogen, but is also supposed to bring considerable from the subsoil by means of its deep roots.

A short rotation sometimes used is wheat, clover, potatoes. A longer rotation quite common in the East is oats, mixed clover, grass, potatoes. A third rotation on hill lands too acid to grow clover is oats, grass, grass, grass, potatoes, the grass not cut the third year but plowed under to furnish organic matter.

Fig. 106.—Intensive potato culture on a Long Island farm, under the "Skinner system" of irrigation.

Applying Fertilizer.—When fertilizer is applied the planting is usually done by machinery. In this case the fertilizer is distributed in the row, either above or below the seed, but not in direct contact. However, it is not considered best to apply more than 1000 pounds per acre in the row, but if more than this is used, to spread a part broadcast, either just before or just after planting.

QUESTIONS

1. Give the relative rank of potatoes and other crops in the world. In the United States.
2. Give the relative production of potatoes in the continents.
3. Compare potatoes and wheat as food crops.
4. Give the principal potato growing States, and yield per acre.

5. Compare with yields in foreign countries.
6. Where are wild potatoes found? When first cultivated in Europe?
7. Describe a potato seed ball; a potato tuber.
8. Name the principal characters used in classifying potatoes
9. How is color of sprouts determined?
10. Name the principal groups of potatoes.
11. Which are generally early varieties?
12. Name the principal groups grown in different regions of the United States.
13. Describe a good market type of potato.
14. Describe the structure and composition of a potato tuber.
15. Describe favorable climatic conditions for potatoes. Where are such conditions found in the United States?
16. Describe effect of hot weather on degeneration of the potato.
17. State advantages generally credited to light soils for potatoes.
18. State the present practice in regard to the use of fertilizers with fertilizer for grass or grain crops.
19. Why is less fertilizer used where potatoes are grown in rotation?
20. State value of lime for potatoes and precautions in using it.
21. Where are the potatoes generally grown in the rotation?

CHAPTER XXXI

CULTURE OF IRISH POTATOES

Cultural methods differ so widely for local reasons that it would not be practical to describe in detail the various methods in practice. Only the most general principles of wide application can be considered.

Source of Seed.—The degeneration of potatoes under hot summer climate has been pointed out. Wild potatoes grow in high mountains where the summer temperature is cool, and cultivated potatoes require the same conditions.

In England, where the summer season is warm, it has long been recognized that seed from Scotland was much more productive and numerous experiments have proven this. The Vermont Station[1] in 1905 imported 13 varieties from England and Scotland and grew them in Vermont for six years in succession. The results in yield per acre were as follows:

	1905	1906	1907	1908	1909	1910
English seed	27.5	54.9	88.4	86.9	103.5	169.5
Scotch seed	82.3	128.3	236.7	159.2	143.1	170.5
Per cent of difference	199.3	133.7	167.8	83.2	38.3	.6

The first three years the difference was very great, but as they were continually grown under one climate, the difference became less until they yielded practically the same the sixth year.

A very interesting demonstration of the principle was made at the Ottawa Experiment Station in Canada. The climate here is usually very favorable, and four varieties which were grown at the station for sixteen years, 1890–1905, steadily increased in yield, as shown by following data:

	Yield per acre, 1890–93, bushels	1902–05, bushels	Gain in bushels
Early Rose	257	317	60
State of Maine	325	361	36
Empire State	301	338	37
Delaware	296	352	56

[1] Vermont Bulletin 172.

Then followed three dry years, in which yield was reduced to one-half, and the potatoes lost vitality and ability to yield. This was demonstrated by importing new seed from Nappan, Nova Scotia, in 1909, and growing beside home-grown seed. Results in 1909 were as follows:

	Rose	Carmen	Vick's extra early
Nappan seed	215	198	171
Home-grown seed	44	83	74

In 1910 seed of eleven varieties from Indian Head was brought in for comparison:

Source	Average yield per acre, bushels
Indian Head seed	368
Home-grown seed	96

Other data could be cited, but the above is sufficient to show the injurious effect of dry, hot weather on vitality of seed.

In general, in the northern tier of States, potatoes retain vitality very well, but further south good seed can only be produced as a regular practice at the higher elevations, in the mountainous districts.

Second Crop Seed.—In the South the difficulty is sometimes overcome by growing what is known as "second crop" potatoes. These are planted about August, and develop tubers during the cooler fall weather. They are killed by frost and harvested green. These potatoes have good vitality, the only objection being that they are rather slow and irregular in germinating when planted the following spring.

Immature Seed.—In Europe it has long been held by many that seed potatoes, harvested green, had greater vigor and productiveness than mature seed. For this reason many growers plant their seed stock late, so the vines are killed by frost before the crop is mature, and use this for seed rather than seed that has normally matured.

Storage of Seed.—Seed stock should be stored in a cool place, and kept solid and perfectly dormant until planting time. This requires a temperature of 30° to 40° F. All potatoes are very dormant when first mature, but they slowly ripen in storage, and,

after two or three months, will sprout readily if temperature is high enough. Potatoes will also shrink if the temperature is too high, and this is also considered injurious. If long sprouts develop in the dark, they are broken off in handling and the second sprouts are not as good as the first.

Sprouting Seed.—Where seed has been held dormant it is good practice to move the seed out into the light in a warm place about ten days before planting (Fig. 107). This will start the eyes into

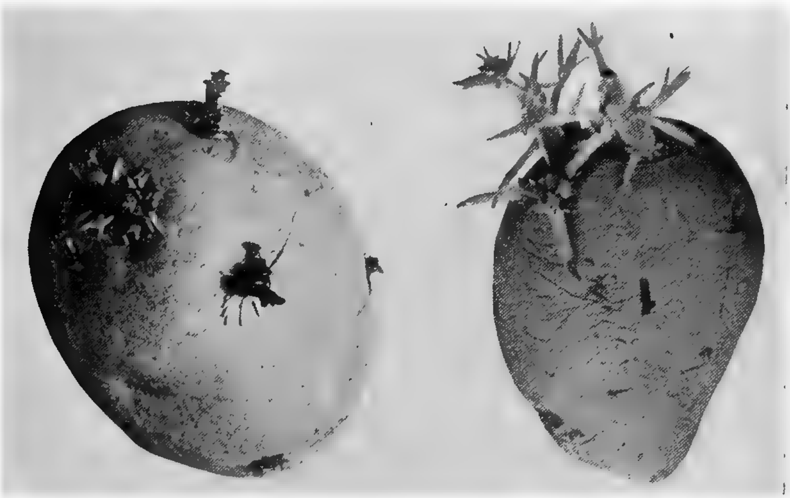

FIG. 107.—Comparing tubers sprouted in strong light and in darkness. Both tubers were taken from same lot and germinated for 30 days. The one on left in greenhouse in strong light, the one on right in dark chamber. Note long, weak sprouts, and shrunken tuber due to germinating in dark. Strong light "greens" the tuber and prevents shrinkage to a large degree.

growth, but the sprouts should not become long enough to become injured in handling. Advantages claimed for this method: (1) any dormant seed can be detected and discarded; (2) the potatoes come up quicker and give a more uniform stand; (3) seed not likely to rot if soil is cold.

Greening Seed.—If potatoes are placed in the light, they turn a greenish color. While the sprouts start, they remain short and stout. Potatoes may be held in the light for two months and remain sound, with short, stubby sprouts. In the light only the strongest

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terminal buds start, and the seed is usually planted whole. This method is used where a very early crop is desired, especially when the planting is done in a cold, wet soil, where seed is likely to rot. Frequent experiments in comparing sprouted or greened seed with dormant seed have usually shown a decided increase in favor of the former. This is especially true with early planting in cold, wet soils.

Amount of Seed to Plant.—In order to give an idea about how much seed is required to plant an acre, the following table is given. The rows are assumed to be three feet apart:

Bushels of Seed Required Per Acre

Size of seed piece Ounces	Hills 12 inches apart	Hills 18 inches apart	Hills 24 inches apart
1	16	12	8
2	32	24	16
4	64	48	32
8	128	96	64

In general, growers in the United States use from 12 to 15 bushels of seed per acre, while in Europe they frequently plant 30 to 40 bushels of seed.

Many experiments have shown that the total yield will increase with rate of planting up to 30 to 40 bushels of seed per acre. However, the percentage of small potatoes also increases with rate of planting under average conditions, and only the most favorable climate and soil justify the heavier planting.

Under average conditions from 15 to 20 bushels of seed per acre will give the maximum yield of marketable potatoes, and as conditions are improved above the average, the planting should be increased. This is illustrated by the following experiment (Ohio Bul. 218):

Relation Between Amount of Seed and Yield of Large and Small Potatoes

Size of seed	Seed, bushels per acre	Yield per acre Marketable bushels	Small bushels	Net marketable above seed planted, bushels
One eye	10	164	25	154
Two eyes	15	204	31	189
One-half tuber	25	217	35	192
Whole tuber	40	223	51	183

It was also shown at the Ohio Station that certain varieties develop more sprouts from the same sized seed piece than others and consequently require less seed. For example, the maximum yield

of Bovee was attained with 15 bushels of seed per acre, while Carmen No. 3 required 25 bushels for maximum yield.

We may then sum up the main factors affecting time of planting as:

(1) Fertility of the soil.
(2) Favorableness of climate for potatoes.
(3) Variety used.
(4) Time of planting.

Whole vs. Cut Seed.—Small whole seed is frequently used for planting, as they are culls from the marketable potatoes and much cheaper. Several experiments comparing whole and cut seed of equal size have usually shown an advantage for the whole seed, though results are variable and the advantage is usually not large under ordinary favorable conditions.

The greatest advantage for whole seed is found in the South, where the early crop is planted in midwinter in cold ground where cut seed is likely to rot. With whole seed only the most vigorous buds at the seed end grow, which is also an advantage under unfavorable conditions. For these reasons large quantities of cull potatoes from Northern crop are used as seed in the West Indies and South Atlantic States for winter planting. In this case the cull seed was grown from large potatoes each year and is quite different from the continuous use of culls year after year from the same crop, as this results in slow degeneration of the stock.

Some growers, however, make a regular practice of growing small whole seed by planting large potatoes very thick. Such seed is very desirable and is preferred for early crop to cut seed.

For the main crop in the North, planted at a favorable time, cut seed from large tubers is to be preferred.

Time of Planting.—In the Corn Belt and southward, planting is early in order to get as much growth as possible before the heat of midsummer. In the North, planting is late to utilize the cool fall weather. For example, in the Corn Belt, planting is general in March and early April, while in New York, the main crop is planted about June first.

Depth of Planting.—The principal considerations are the

effect on quality and yield of crop, and expense of planting and digging.

Deep planted potatoes are considered of best quality, as they are smoother, none are sunburned, and they are more uniform.

Yield is usually improved with planting 4 to 5 inches below the level surface, rather than shallower. As pointed out heretofore, new tubers arise from underground stems that are produced at the nodes. It is claimed that deep planting, by increasing the number of underground nodes, favors larger yields. This theory, however, has not been well substantiated. Deep planting is a disadvantage in cold, wet soil, when quick germination and an early crop is desired. For this reason early potatoes should be planted shallow though they may be covered deeper after germination.

In practice, potatoes are commonly planted shallower than four inches, in some regions only two inches below the level. Where shallow planting is practised, the soil is ridged up about the plants in cultivating in order to provide plenty of room for the tubers, and prevent sunburn. The principal reason for shallow planting is ease in harvesting, especially where hand digging is practised.

Hill vs. Drill Planting.—Where machines are used, drill planting is the general practice, and, while there is little experimental evidence, probably gives better yields, especially where large quantities of fertilizer are used, as the roots have a more uniform distribution in the soil.

Hand planting is practised where the area grown is small, or where hills are too steep for machines. In some regions, as northern New York, the vines are so heavy that hand-digging is necessary. Where machinery can not be used, hill planting has several advantages: (1) easier to plant; (2) takes less seed; (3) easier to cultivate; (4) easier to dig.

Level vs. Ridge Cultivation.—It is the general custom to throw up a rather high ridge around the potato rows or hills. It is easier to kill weeds by high ridging, and also makes digging much easier. While deeper planting and level culture usually give somewhat greater yield, the labor cost is greater and generally believed to offset the prospect of higher yield. The ridging, however, can

be too high, injuring some roots between rows, and the best growers say that a moderate ridge, 4 to 5 inches, is best.

Tools for Cultivation.—The harrow or weeder is often used first, even before the potatoes are up if weeds appear or the ground is crusted by rains. The use of the harrow and weeder may be continued until the crop is six inches high. This is followed by cultivators (Fig. 108), usually with narrow blades, to give a fine, even surface. If weeds start in the row, considerable earth is ridged up to cover them.

FIG. 108.—A good type of cultivator. The rows have already been ridged with a hiller.

One light hoeing is usually necessary to kill all weeds. Cultivation is usually continued until the vines cover the ground. In many places a sweep plow is used the last going over, to ridge up and make sure that no tubers will be exposed to the sun. This practice is most common on shallow, gravelly soils, where the potatoes normally develop very near the surface. In deep loam soils the sweep is seldom used.

Harvesting the Crop.—Special harvesting tools have evolved from the older farm tools (Fig. 109). The spade has developed into the potato fork, the hoe into the potato hook, while in the plow the mould-board has been replaced with iron rods in the simplest form

of horse-digger, while elevators and sorters have been added in the larger diggers.

About one-half or more of the potato crop is dug by hand. The hook is used mostly on sandy or gravelly soils where the tubers are shallow, and the ridge method of culture is practised. The potato fork is used more in the Western States on deep loam soils, where more level culture is practised and the tubers are deeper.

The horse-diggers are generally used where acreage is large and the land level, except in some northern regions like northern New York, where the vines are very heavy and usually green at digging time.

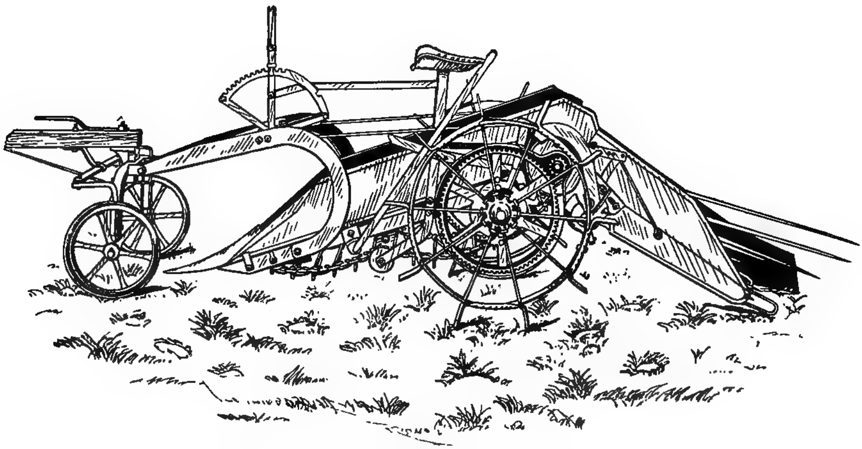

FIG. 109.—A large potato digger.

Storage.—Potatoes are usually stored in cellars, field pits, or cold storage warehouses.

The principle of good storage is to keep them cool, dry, and with good ventilation to carry off moisture as the potatoes dry.

Changes in Storage.—In storage, potatoes undergo certain changes. Potatoes when first ripe, will usually not germinate, but they undergo a slow process of maturing under storage, and will usually germinate freely in two to three months. This is known as the dormant period. The cooking quality also changes, the potatoes becoming more mealy when cooked, as they mature under storage.

Shrinking in Storage.—Potatoes always lose weight in storage. The loss is slow at first, usually amounting to 6 or 8 per cent in good storage during the first six months. After that the loss is much faster and will sometimes amount to 4 or 5 per cent a month in the spring under ordinary cellar conditions where the temperature can not be kept down.

The loss is due to two causes: (1) Loss of water, and (2) loss by respiration. Loss by respiration is due to the slow conversion of starch into sugar and finally breaking up and passing off as carbon dioxide gas. Experiments have shown that about 75 per cent of the loss is due to water loss and about one-fourth due to respiration.

Cold Storage.—The loss by respiration also goes on in cold storage, but at temperatures below 32° F., the sugar developed does not undergo further change but remains, giving the potato a sweetish taste. This is the reason cold storage potatoes or slightly frozen potatoes are sometimes sweet.

For table stock potatoes should be held at 40° to 50° F., while seed stock is held at from 32° to 40° F.

Diseases and Insects.—The potato plant is subject to a large number of diseases. Many of these do little injury, but at least a dozen are severe in some part of the world where potatoes are grown.

No potato disease is universally injurious, but is limited to certain regions. All of the diseases are influenced by climate or soil, and hence vary in their injury from year to year.

For example, the late blight is perhaps the most injurious disease, yet there are large regions, as the Southwest, where it is seldom seen. Even in the eastern States, where it is very common, there are considerable areas in which late blight is seldom found. Other diseases are not considered as serious in northern climates, as the State of Maine, but southward are very injurious.

A brief summary of the principal diseases is given below:

A. Affecting the foliage only:

1. Early blight, caused by *Alternaria solani.*
2. Leaf blotch, caused by *Cercospora concors.*

B. Affecting chiefly the stems:

3. Brown rot, caused by *Bacillus solanacearum.*
4. Black leg, caused by *Bacillus phytophthorus.*

5. Stem blight, caused by *Corticium vagum.*
6. Fusarium wilt, caused by *Fusarium oxysporum.*
7. Verticillium, caused by *Verticillium albo atrum.*

C. Affecting the tubers chiefly:

8. Common scab, caused by *Streptothrix scabies.*
9. Powdery scab, caused by *Spongospora subterranea.*
10. Wart disease, caused by *Chrysophlycetes endobiotica.*
11. Dry rots, caused by several species of *Fusarium.*

FIG. 110.—In the foreground is a spot where a dozen plants, in a good field, have been killed by the disease rhizoctonia.

12. Bacterial soft rots, caused by *Bacillus solanacearum* and *B. phytophthorus,* and other bacteria.
13. Leak, caused by *Rhizopus nigricans.*

D. Affecting all parts of plants:

14. Late blight, caused by *Phytophthorus infestans.*

Unfavorable climate, usually hot, dry weather, causes sun scald and tip burn. Arsenical poisoning sometimes results from spraying.

Of the above diseases, the common scab is most abundant, but not very injurious. Late blight is the most destructive disease, and probably black leg is next.

Controlling Tuber Diseases.—The diseases transmitted on the exterior of the tuber are treated by soaking in some disinfectant that will destroy the disease, but not the eyes of the potato. Common scab and rhizoctonia (Fig. 110) are the most common diseases transmitted on the tuber. The common treatment for scab is to soak tubers in formalin solution (one pint to 30 gallons of water) for one hour. This, however, will not kill rhizoctonia. Black leg is killed by corrosive sublimate solution—one ounce to seven gallons of water, soaking the seed for ten minutes.

FIG. 111.—A power sprayer, that will spray seven rows at one time.

As the latter treatment will also kill scab, it is advisable to use the corrosive sublimate treatment, thus treating against both diseases at once.

Controlling Vine Diseases.—Late blight is the principal vine disease to be contended with. This is controlled by the use of Bordeaux spray mixture (Fig. 111). Late blight (Fig. 112) is a fungous disease, growing on the outside of the leaves, and is killed by a very weak solution of copper sulfate, which, however, does not injure the leaf if properly neutralized by lime.

The strength of the Bordeaux mixture is expressed as 3–3–50 or

5–5–50, meaning in the latter case, that it is made with 5 pounds of copper sulfate, 5 pounds quicklime and 50 gallons of water. Bordeaux is made as follows:

Stock solutions are first prepared. Slack quicklime by slowly adding water until in a fine powder, then make up into a thin paste.

Copper sulfate solution is made by suspending in a coarse sack in the top of water, as the solution is heavier than water and it will not dissolve in the bottom of a vessel.

One gallon of water will dissolve three pounds of copper sulfate. This is called a concentrated stock solution. A barrel of each stock solution can be made at one time, as it will keep a long while.

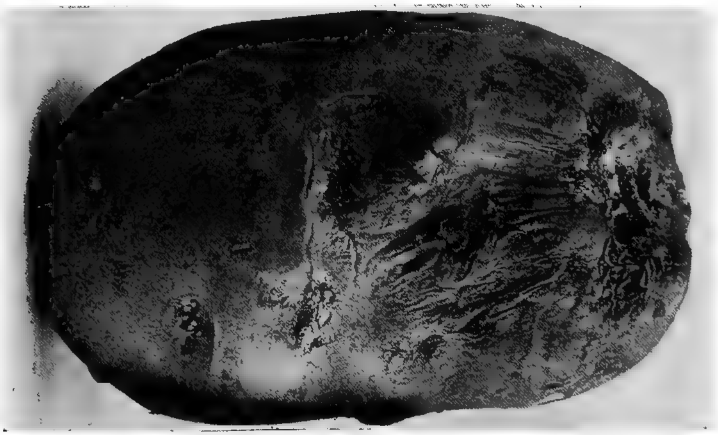

FIG. 112.—Potato affected with the rot, resulting from late blight.

Mixing Bordeaux.—To mix, place two barrels on a platform somewhat higher than the spraying mixture. To make a 3–3–50 solution, take one gallon of copper sulfate solution and mix with 25 gallons of water in one barrel; in the other barrel mix enough lime paste to equal 3 pounds with 25 gallons of water; then allow both solutions to run at one time into the sprayer tank. The strength of spray used varies from 3–3–50 to 5–5–50, using the stronger mixture when the disease is giving trouble or there is trouble from rains washing off the mixture.

Testing the Mixture.—When the mixture is made, take out a

sample and test with a few drops of potassium ferrocyanide solution. If the solution turns brown, there is not enough lime, but there will be no change if there is enough lime. There should be some excess of lime to be sure the copper is neutralized, but not too much, as the lime will clog the nozzles. Lime is used to neutralize the copper so it will not burn the foliage, and also to make the solution more adhesive.

Time of Spraying.—No rule can be given as to the time to begin spraying, except it should be done before the blight has opportunity

FIG. 113.—A good field of potatoes. Sprayer at work in the distance.

to attack the crop. The blight may make its first appearance any time from midsummer to the very end of the season, or not appear at all. In hot, dry weather there is less danger than in wet or humid weather, and conditions must be watched closely.

Generally, it is best to give the first spraying when the plants are less than a foot high, in order to cover all the lower leaves. Apply other sprayings according to the weather or rapidity of growth (Fig. 113).

The number of sprayings given in practice varies from 3 to 10. If the disease is present, and weather damp, it is generally agreed

that one spraying a week should be given. It is best to spray just after a rainy period rather than before, in order to cover the new growth.

Stimulating Effect of Bordeaux.—Bordeaux mixture has a decided stimulating effect on potato foliage, and it has been frequently observed to increase yield even when no disease appeared. The increased yield usually pays the cost of spraying, even without blight.

Insects and Insecticides.—For the potato beetle and leaf-eating insects it is customary to use an arsenic poison, either as Paris green or lead arsenate. When spraying with Bordeaux for blight, the poison may be added to the Bordeaux mixture at the rate of one-half to one pound of Paris green per 50 gallons, or 3 to 5 pounds of arsenate of lead. As Paris green is sometimes injurious to foliage, being slightly soluble in water, it is generally preferred to use arsenate of lead, which is absolutely insoluble.

For spraying poison without Bordeaux, it is mixed at the same rate with water.

Potato Improvement and Breeding.—Very few varieties of potatoes popular 30 to 40 years ago are in use to-day. Old varieties are constantly replaced with new and more vigorous sorts, or improved strains of the old.

Origin of New Varieties.—New varieties originate in three ways: (1) by growing new plants from seed balls; (2) by sports or mutations, thus at once producing a new variety by bud variation; (3) by systematic selection, taking advantage of small variations.

Potatoes from Seeds.—Seed balls may be produced naturally, or may be the result of cross fertilization, thus producing hybrids. However, many cultivated varieties rarely produce seed balls.

If the seed is planted, rather small plants are grown the first year. Each plant will, on the average, produce two or three small tubers, usually not larger than marbles, but occasionally full sized tubers.

The first crop from seed is usually quite variable and permits of considerable selection, and many new varieties have been produced in this way. The second or third year the tubers reach full size and usually remain quite true to type.

Sports or Mutations.—Sports, now called mutations, are new

forms appearing suddenly from an old established form—for example, a white potato in a hill of red variety, or a long potato in a hill of round variety. Such sudden appearances of new types are recorded and have been preserved, giving us new varieties.

Systematic Selections.—Plant breeding is simply a systematic way of finding the small variations, either for better or worse, that are constantly taking place. For example, if 100 potato tubers be selected and each planted in a separate hill, it will be found at harvest time that certain tubers have produced two or three times the yield of others. The difference is to a large degree hereditary, so if the highest yielding hills are saved for seed, a more productive stock is at once secured. This practice of planting a certain number of tubers separately and selecting only the best producing hills may be continued from year to year with gradual improvement. It is best to use rather large tubers and cut each into four parts, as four hills from each will give surer results than to have only one hill from each.

Outline for Describing Potatoes

Variety:
1. Early, medium, late.

Shape:
2. Oblong, round, oblong-flat, oval-round, oval-flat.
3. Regular, irregular.

Size:
4. Large, medium, small.
5. Uniform, not uniform.

Eyes:
6. Deep, medium, shallow.
7. Oval, narrow, elongated.
8. Large, small (as compared with size of tuber).
9. Numerous, medium, few.
10. Uniformly distributed, mainly at bud end.
11. Ridge prominent, ridge not prominent.

Sprouts:
12. Color—yellowish-white, pink, blue, purple.

Skin:
13. Smooth, rough, netted, lenticelled.
14. Color—yellowish-white, light russet, dark russet, red, pink, blue.

General Characteristics:
15. Sample, clean, dirty.
16. Cracked, not cracked.
17. Disease present, disease absent; if present, scab, dry rot or blight; rhizoctonia, sunburn, grub, or wilt.
18. Bruised or not bruised.
19. Mature, immature.

Flesh:
20. White, yellowish, pink.

Structure

Cortical Layer:
  21. Thick, thin.
External Medullary Area:
  22. Proportion—large, small.
Internal Medullary Area:
  23. Large, small.
  24. Branched much, branched little.
  25. Light, dark.
Estimated Cooking Quality:
  26. Mealy, medium, soggy.

LABORATORY EXERCISES

STUDY OF POTATO TYPES

Directions for Report.—*Describe* each of the 11 samples of potatoes exhibited, using the accompanying descriptive key and blank outline. The samples here shown and described represent approximately the characteristics of each of the main variety groups.

Draw natural size the long broadside view of a tuber of each of the above groups, paying special attention to size and shape of tuber, size, shape and distribution of eyes.

Draw natural size the transverse section of a tuber of each of these groups, paying special attention to relative proportion of cortex, internal and external medullary areas.

Label all parts carefully in right hand margin.

From your knowledge of descriptive characteristics of èach of the main groups, *list* the *extra varieties* exhibited under the proper group, *i.e.*, Irish Cobbler, Triumph, Rural, Early Michigan, Rose, Hebron, Burbank, Early Ohio, Green Mountain, Pearl and Peachblow.

MORPHOLOGY AND COMPOSITION OF THE POTATO TUBER

The potato tuber as a part of the system of lateral underground stems, corresponds largely in its morphology to aërial stems. It serves as a storage part to the underground stem and enables the plant to live over from one year to another.

Note (*a*) stem end; (*b*) bud end; (*c*) eye buds; (*d*) eyebrows; (*e*) arrangement of eyes with reference to stem and bud end.

Draw a tuber natural size showing correct arrangement of eyes and labelling stem end, bud end, eyes and eyebrows.

Indicate on your drawing by dotted lines how the tuber should be cut for seed purposes. By a dash line indicate the phyllotaxy of the tuber.

Make with a sharp knife, a *thin* longitudinal and a thin transverse section of a tuber, cutting through one or more eyes in each case. Rinse in water and examine carefully.

Observe and *draw* natural size in both longitudinal and transverse section a tuber showing in proper proportion (*a*) internal medullary area; (*b*) external medullary area; (*c*) cortex; (*d*) epidermis.

Treat a thin longitudinal section with iodine (5 per cent solution), rinse in water and *observe* the portion of greatest starch concentration. *Indicate* by labelling in your drawing.

Answer the following subsequent to reading Farmers' Bulletin No. 295, pp. 5–13, and Cornell Bulletin No. 230, pp. 508–512.

1. What differences in composition of the external and internal medullary areas?

2. What mainly is the composition of the cortex? Of the epidermis?
3. What relation between internal medullary area and eyes?
4. (*a*) What constitutes texture in a tuber? (*b*) What indicates fine texture in a tuber? (*c*) What indicates coarse texture in a tuber?

QUESTIONS

1. Describe the experiments conducted at Vermont and Ontario, Canada, on the source of seed.
2. What merits are claimed for "second crop" seed? For immature seed?
3. Why is low storage temperature required?
4. Will potatoes sprout better after storage?
5. What advantages claimed for sprouting seed?
6. How much seed required to plant an acre?
7. Does yield vary with rate of planting?
8. Under what conditions is whole seed used rather than cut seed?
9. How is time of planting regulated?
10. Compare the merits of deep and shallow planting. Of hill and drill planting. Of level and ridge cultivation.
11. Give the ordinary practice in cultivating a potato crop.
12. What tools are used in harvesting?
13. What changes take place in storage?
14. Give temperature for storing seed stock. Table stock.
15. What are most destructive diseases?
16. What is the nature of a "disease"?
17. Name several diseases.
18. Give treatment for scab and rhizoctonia.
19. How is late blight controlled?
20. Tell how to make and test Bordeaux mixture.
21. When is the spray applied?
22. Does Bordeaux have any other effect beside killing the diseases?
23. Give treatment for potato bugs.
24. How are new varieties originated from seed balls?
25. What are sports?
26. Describe method of potato breeding by hill selection.

CHAPTER XXXII

SWEET POTATOES

THE sweet potato belongs to the Morning-Glory family. It is of tropical origin, probably coming from the West Indies or South America. The plant is a perennial and seldom blossoms or produces seed in the United States. The blossom is very much like that of a large morning-glory and is of a purple color (Fig. 115). In the North sweet potatoes are treated as an annual, and not as a perennial.

The Roots.—The sweet potato differs from the Irish potato in

FIG. 114.—A single sweet potato from the hot-bed, showing many young sprouts. Note the difference in the size of young plants. (Experiment Station, New Jersey.)

being a true root. The Irish potato is an enlarged underground stem, its various parts being analogous to the stems above ground. The sweet potato, however, is an enlarged root.

Origin and History.—Very little is known about the early history of the sweet potato, except that it was in general cultivation by the natives of South America when first visited by white men. The wild form has never been discovered. The sweet potato has attained considerable culture in foreign countries, especially in China and islands in the Pacific Ocean. Its culture has had a slow development in the southern States, but within the last two decades the

use of the sweet potato as a truck crop has had a rapid development. It is now the most important vegetable next to Irish potatoes.

Types and Varieties.—While there are many varieties of sweet potato, no very satisfactory classification has ever been worked out. They are sometimes placed in two groups, called vine and vineless potatoes, the term " vineless " applied to the varieties having a short, upright vine. It has also been attempted to subdivide the groups on the shape of the leaf, as certain types have deeply-lobed cut leaves, and others regular leaves with uniform edges; but this is not a satisfactory character to use. They may also be grouped as dry and moist or syrupy types. The dry types are usually grown in the North and are represented by the Jersey Yellow variety. In the southern States the varieties with soft flesh, sometimes called watery or syrupy, are usually preferred. Most of the varieties of so-called "yams" in the South belong to this group. They may also be grouped according to color of tuber, as white, yellow, or pink. Probably a hundred varieties of sweet potatoes are cultivated, but not more than a dozen of these are very extensively grown.

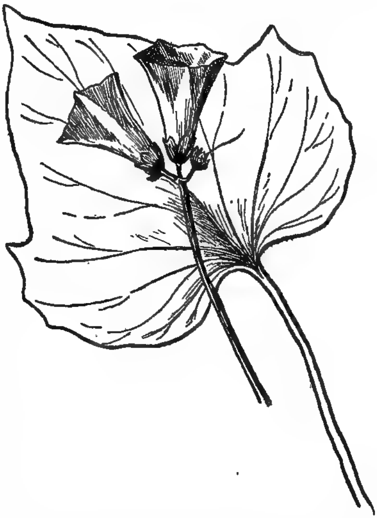

Fig. 115.—Sweet potato leaf and blossom.

Market Types.—The northern market usually demands a rather dry sweet potato, of medium size, and not very long (Fig. 116). The yellow color is generally preferred. The most important varieties in the northern market are the Big-stemmed Jersey, the Yellow Jersey, and Red Jersey. The first of these varieties is the most productive and preferred by the truck growers, but the latter two are of a better quality and suitable for the home garden. In the southern States the Hayman, a soft-fleshed variety, is very popular. Several of the yams, which differ from the ordinary sweet potato in being short and thick, somewhat larger, with a moist, syrupy flesh,

are extensively grown in the South for home use, such as the pumpkin yam, the Georgia yam, and the Florida. Two or three other varieties, such as the Black Spanish and Red Bermuda, are grown for stock feed, due to their great productiveness.

Where Sweet Potatoes Are Grown.—Over ninety per cent of

FIG. 116.—Some commercial types of sweet potatoes: left to right, long, cylindrical type; Jersey group; red Bermuda; southern Queen.

the crop is grown in the South. The ten leading States in 1909 were as follows, according to the Census:

Sweet Potato Production, 1909

States	Acres	Per cent increase in ten years
United States	641,255	19.3
North Carolina	84,740	23.3
Georgia	84,038	19.0
Alabama	66,613	31.0
Louisiana	56,953	108.1
Mississippi	56,045	46.8
South Carolina	48,878	0.1
Texas	42,010	3.6[1]
Virginia	40,838	0.4
Tennessee	26,216	12.2
New Jersey	22,504	9.3

The average increase for the United States since 1899 was 19.3

[1] Decrease.

per cent. Texas was the only State growing a large acreage to show a decrease.

Climate for Sweet Potatoes.—The sweet potato requires very warm, sunshiny weather for good growth. For best results it should have abundant rain during the first half of its growing period, but somewhat dry weather as it matures. If there is too much rain during the latter part of the growing season, it is inclined to develop a large growth of vines, with many small potatoes of poor quality. In general, the climatic conditions found in southeastern United States is quite favorable to the sweet potato crop.

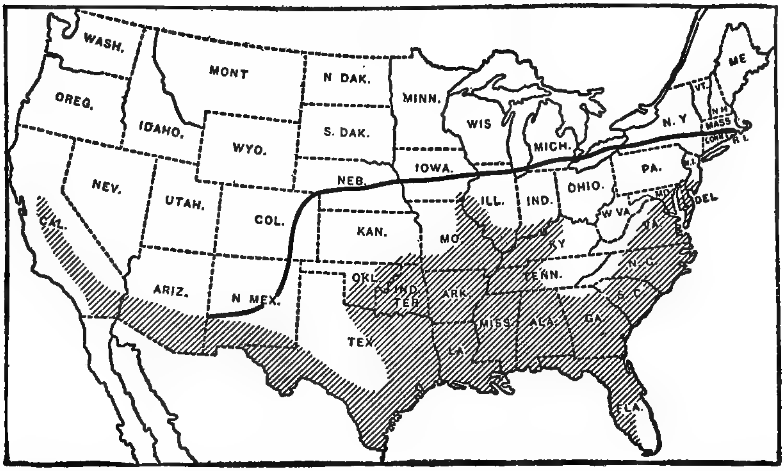

FIG. 117.—Map showing range of production of sweet potatoes. The shaded portion shows the area adapted to commercial growing. The dark line represents the northern limits of sweet potato culture for home use. (From U. S. Farmers' Bulletin 324.)

Soil for Sweet Potatoes.—Sweet potatoes can be grown profitably on many soils where the majority of farm crops would fail. This is especially true if the soils are sandy, as they do remarkably well in sandy soil. Sweet potatoes also respond very quickly to commercial fertilizers, and do not require so much organic matter in the soil. This makes it possible with the use of commercial fertilizers to grow sweet potatoes throughout the southern States on much of the light or sandy soil. The largest crops are grown, however, where a reasonable amount of organic matter is kept in the soil by means of manure or green crops plowed under in connection with a fair dressing of fertilizer. While sweet potatoes will do fairly well even

on heavy soils, the lighter type of soil is considered decidedly better. Good drainage is especially important for sweet potatoes, and this is one reason why in many places they are frequently grown on high ridges. Sweet potatoes on wet land are usually coarse and poor in quality.

Manure and Fertilizers for Sweet Potatoes.—If barnyard manure is used, it should be well rotted and usually applied to the previous crop, although in light, sandy soils it is very commonly applied directly to the sweet potato crop. Barnyard manure is very beneficial to exhausted soils, but with fairly fertile soil it is probable that better results can be secured by the use of commercial fertilizers. Where sweet potatoes are grown as a regular crop, it is considered very beneficial to turn under a green manure crop about a month before planting the sweet potatoes. Crimson clover is generally agreed to be about the best crop for this purpose.

Sweet potatoes respond exceptionally well to commercial fertilizers, and they are generally used in growing the crop on sandy land. It is generally believed that on sandy lands potash is of the greatest importance, and phosphate next, in making the fertilizers for sweet potatoes. Some nitrogen should be supplied, but not an excessive amount, as it would stimulate too large a growth of vines. In general, a fertilizer containing about four per cent of nitrogen, six to eight per cent of phosphoric acid, and eight to ten per cent of potash is recommended. On clayey soils, however, the per cent of potash can be somewhat reduced to advantage.

Applying Fertilizers.—Ordinarily about 300 to 400 pounds of fertilizers are applied per acre, but in the trucking regions along the Atlantic Coast 1000 or 1200 pounds are frequently applied. When 300 or 400 pounds are used, it is generally applied under the sweet potato row a week or two before planting, but the larger amount is generally applied broadcast.

Preparation of Land.—The sweet potato crop should be grown in a regular rotation, coming on the same land not oftener than once in three or four years. It is best to precede the sweet potatoes with a cultivated crop, such as corn or cotton, in which a cover crop, such as crimson clover or hairy vetch, has been fall-sown. The plowing under of such a cover crop seems to be an ideal preparation for sweet potatoes.

The depth of plowing will be controlled somewhat by the character of the soil. On very deep, loamy soils it is not always desirable to plow deeply, as it tends to make the sweet potatoes long and spindle-shaped. The market requires a rather short, well rounded potato. On deep soils sometimes the plowing does not exceed four inches in depth, but experience on each type of soil is the best guide in depth of plowing. On soils with compact clay subsoil there is little danger from deep plowing.

Ridging and Level Culture.—Sweet potatoes are most commonly planted on ridges. These ridges are commonly prepared by first opening up a furrow, in which 200 to 400 pounds of fertilizer per acre is distributed. This furrow is then covered with a back furrow, forming a sharp ridge. Just before planting this ridge is partly levelled with a board scraper or harrow, giving a nice moist soil in which to put the plants. The subsequent cultivation maintains the ridge. There is no very good evidence that the ridge method is superior over level planting, and many growers fit the land without ridging, and give level culture. On wet or cold soils the ridging method probably has some advantage, but in other cases it is largely a matter of convenience and choice on the part of the grower. Probably the greatest advantage claimed for the ridging system is that it facilitates digging.

Propagation of Plants.—Sweet potatoes are propagated in two ways: (1) by plants grown directly from the roots; (2) by slips cut from growing vines. All the early crop is grown from plants, but many growers will produce a part of their late crop from slips. Plants are grown mostly from the smaller sized potatoes sorted from the main crop. Whether using these small potatoes continually will have the effect of reducing the crop in time has never been demonstrated, but since the custom has been long in practice without apparent ill effect, it is believed they are satisfactory seed. It is the custom, however, to throw out all the misshapen roots and use only smooth and shapely potatoes of small size. Most growers prefer "slip seed" rather than that grown from the regular crop, as it is usually free from disease and thought to produce more vigorous plants. For this purpose many growers put out a small area of slips each year for growing the seed stock.

Preparation of the Hot-bed.—The hot-bed should be prepared from four to six weeks before the sets are wanted. The commonest method is to prepare a shallow excavation of the proper size. In the bottom of this six to eight inches of fresh barnyard manure is well tamped in. This is covered then with about three or four inches of loose, sandy soil. It is best not to plant until the hot-bed has had time to reach its maximum heat and cool down again to a temperature of 90°. This will usually take about four days. The seed potatoes are then placed in the hot-bed, either by laying them on their sides, as closely as they can be placed, or else by pushing them into the soil in an upright position. The bed should then be covered with sandy soil, so that the potatoes are about two inches below the surface. The hot-bed should be kept well watered, but not saturated, as there is some danger of the seed rotting; however, it is very important that the bed never be permitted to get dry, as it will greatly reduce the number of plants (Fig. 118).

Fig. 118.—Sweet potato plant ready to set in field.

Number of Plants.—In estimating the size of the hot-bed, from forty to fifty square feet should be allowed for each barrel of seed. A barrel of seed should produce 5000 plants on the first pulling, and a total of 8000 or 9000 when the second and third pulling are completed. As it takes about 10,000 plants for an acre, the grower

should allow two barrels to the acre if he wishes to plant all from the first pulling, or one barrel to the acre if he utilizes his second and third crop of plants. The first crop of plants should be ready in five or six weeks; the second crop ten days or two weeks later; and the rest of the plants will be removed in about two weeks more.

Pulling the Plants for Planting.—The plants should be pulled in such a way as not to disturb the seed. As soon as pulled, it is best to dip the plant roots into a thin paste made from clay and cow manure. They should then be packed closely into crates in an upright position. As soon as the plants have been pulled, the beds should at once be wet down, in order to settle the soil and stimulate the new growth of plants.

Setting the Plants.—It is generally considered best to set the plants if possible during a rainy season; however, if the land has

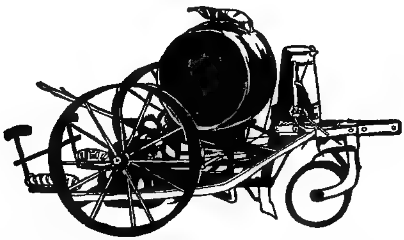

Fig. 119.—Transplanting machine.

been handled in such a way as to conserve the moisture, it is possible to set the plants with fairly good results even in a dry time. Where ridges have been prepared a week or two in advance, they should be scraped down to moist soil just before planting. Where transplanting machines are used (Fig. 119), however, they are fitted to deposit a quantity of water with each plant, and hence planting may take place at any time.

Hand planting is generally practised where the area is not too large, but transplanting machines are used for large acreage. Many simple devices are used to assist in hand planting. The plants are usually distributed along the row a proper distance apart, just ahead of the planter. If it is a rainy period, the plants may be set by simply placing a blunt stick on the root end of the plant and pushing it into the ground. Where more care is required, the soil is usually

opened wth a small trowel or dibble, and the plant well pressed into the soil. A good, expert man can set by hand one acre a day if the plants are distributed for him. Four to five acres a day can be planted with a transplanting machine.

Distance Apart for Plants.—Sweet potatoes are usually placed in rows three and one-half or four feet apart, although the vine-less or bunch varieties may be set somewhat closer. It is a common practice to space them eighteen inches apart in the row, although on rich land, where the potatoes are likely to be over-sized, it is an advantage to set somewhat closer. The above spacing will require about 10,000 plants per acre.

Cultivation of Sweet Potatoes.—The ordinary tools used for cultivating corn or cotton are well adapted for use in the sweet

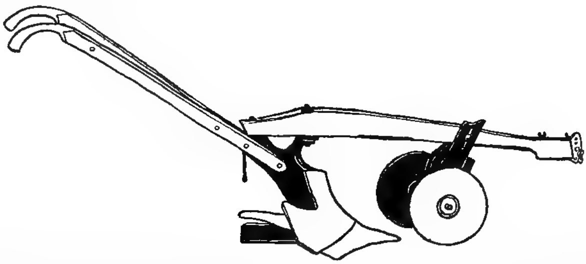

FIG. 120.—Special plow, fitted with two rolling coulters for digging sweet potatoes.

potato crop. Usually one hoeing is required to clear grass and weeds from the rows. Late in the season when the vines become long, it is sometimes necessary to lay the vines aside for the last cultivation. Some cultivators have an attachment for lifting the vines at the last cultivation.

Harvesting.—The time of harvesting depends somewhat on market demands. In trucking sections they may begin harvest when the first potatoes are large enough to market, but the crop is always cut short, as the smaller potatoes continue to grow for several weeks after this period. The standard varieties are usually harvested in about four and a half months after planting. It is best to harvest before severe frost. If the vines are killed by frost and not cut off at once, the rotting vines will soon injure the sweet potatoes.

Tools for Harvesting.—The plow has been modified in many ways for harvesting sweet potatoes (Fig. 120). Generally a rolling coulter is put on the plow to cut the vines. With such a plow the first furrow may be run with the land side next to the sweet potato row, while the second furrow is gauged to turn out the potatoes. Also plows are fitted with two rolling coulters spaced about twelve inches apart, and the sweet potato row may then be turned out with the first furrow. The regular large potato digger used for digging Irish potatoes can also be used for sweet potatoes, but is not altogether satisfactory, as it usually bruises them up more or less.

Storing Sweet Potatoes.—Methods of storing sweet potatoes vary, from placing them in very simple pits to well equipped and especially built warehouses. The main principle in storing is to first cure the potatoes, which really means drying out the excessive moisture, and takes three to four weeks. The moisture should be dried out at rather high temperature, anywhere from 80° to 100°. After this the potato should be slowly reduced to a temperature of 50° or 60° and held without disturbing until used. To facilitate the curing or drying out, provision must be made for ventilation, and if they are to be cured in large quantities, usually provision must be made for heating.

Construction of Pits.—A simple outdoor pit is made by first digging a slight excavation in a high, elevated place. If the pit is a large one, ventilation should be provided in the bottom by making shallow trenches covered with slats or brush, with a board ventilator in the center. The potatoes are piled in the pit and lightly covered with straw until they have gone through the sweating process. They may then be more heavily covered with straw, and when cold weather comes, a covering of dirt. Permanent board covered pits are also made in a simple way and are satisfactory if good provision is made for ventilation.

Where large warehouses are built (Fig. 121), the walls are made reasonably tight, but good provision is made for ventilation. Slatted bins are made in the warehouse, so that there is circulation of air underneath the bins and on all sides. Usually some provision is made for heating, so that a circulation of warm air can be kept up

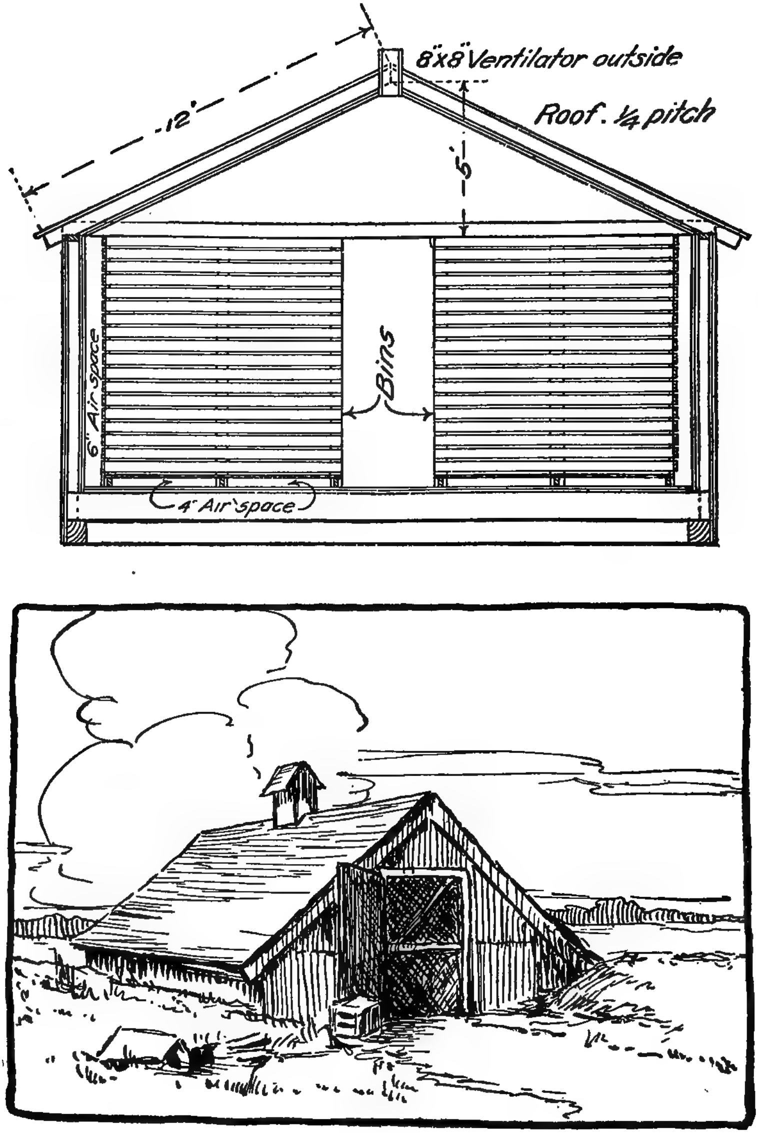

FIG. 121.—Storage houses. Upper figure, a large ventilated storage house. Lower figure, a covered pit or cellar. (From U. S. Farmers' Bulletin 548.)

while the potatoes are curing. As long as moisture condenses during cool nights on the roof or walls of the warehouse, good ventilation should be provided, but when the potatoes have been well cured, the house may be shut up reasonably tight, and they will generally keep for several months. Disturbing the potatoes causes them to rot, so that a bin should be marketed as soon as it is opened.

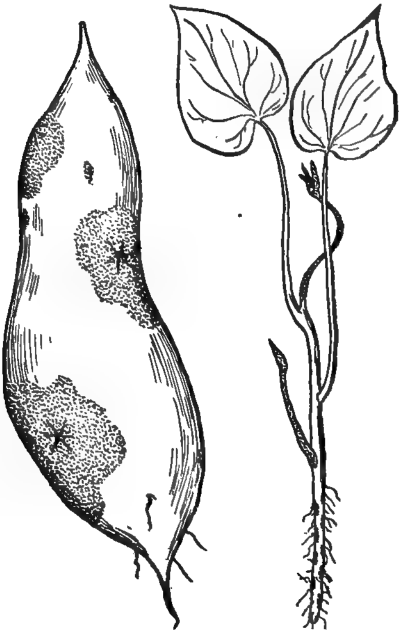

FIG. 122.—Sweet potato affected with black rot, and plant affected with same disease. (After Halstead, New Jersey Bulletin 76.)

Diseases and Insects.—The sweet potato is quite free from injurious diseases and insects. The most destructive disease is known as black rot. Black rot (Fig. 122) gives some trouble in the field, but is most injurious in the warehouses. It appears as rather large black spots on the potato, soon causing the rot. The principal method of control is to provide against infection in the field. It is usually carried over in the soil or on the plants. Great care should be taken to use seed free from the disease. For this reason many growers use seed grown from slips, planting it in soil

where potatoes have not been grown in recent years, in this way getting disease-free seed. Other rot diseases, known as stem rot, soft rot, and dry rot, are less common, but similar in their attack to the black rot. They are all controlled much in the same way,—namely, rotation of crops and use of clean seed.

The sweet potato borer is the only insect that injures the plant to any extent. Its injury is caused by boring through the sweet potato tubers, and sometimes it is the cause of considerable injury along the Atlantic Coast.

LABORATORY EXERCISES

SWEET POTATOES

1. Compare the structure and anatomy of a sweet potato and Irish potato tuber. Does the sweet potato have similar cortical and medullary parts? Does it have the same kind of eyes? (See laboratory exercise on Irish potatoes.)

Draw longitudinal sections of sweet potato and Irish potatoes.

Place both sweet potato and Irish potato in a moist chamber in a warm, dark place. Make drawings illustrating the origin of sprouts on both.

2. If possible the students should take part in making a hot-bed, setting plants or in any other field operations that may be under way in the neighborhood.

3. Storage Experiment.—Place a half-bushel of freshly dug sweet potatoes in a tight box or can, and a second lot in a ventilated crate. Make notes on comparative keeping quality under the two conditions.

QUESTIONS

1. How does the sweet potato resemble the morning-glory?
2. Compare the tuber of the sweet potato and the Irish potato.
3. Give the history of sweet potatoes.
4. Describe the principal types of sweet potatoes.
5. Where are sweet potatoes grown principally?
6. Describe best climatic and soil conditions.
7. State the best manure and fertilizer treatment for sweet potato land.
8. Compare merits of ridge and level culture.
9. Describe briefly all the details in propagating sweet potato plants.
10. Describe methods of setting plants.
11. Describe methods of harvesting.
12. Principles to be observed in storing.
13. Describe construction of pits. Storehouses.
14. Describe the principal diseases and their control.

CHAPTER XXXIII

CLASSIFICATION AND DISTRIBUTION OF FORAGE CROPS

Forage, in the broadest sense, means any kind of feed for stock, including cereals or by-products, as well as hay or pasture plants. In common usage, however, forage means plants that are fed whole, in either the green state or dried state. Grass, millets, clover, and alfalfa are always called forage plants. Root crops grown for stock feed are also spoken of as "forage roots."

Corn is considered a grain crop in the corn belt, but when the whole plant is harvested and cured as fodder or put in the silo corn is considered a forage crop. Also oats, wheat, and barley are often cut before mature and cured as hay, when they are classed as forage.

Classification of Forage Crops.—In taking the Census the United States Government has classed the forage plants into certain convenient groups. The classes and their relative importance are shown in the following table:

Acreage, Production and Value of Hay and Forage for 1909 by Classes

	Acres	Production	Value
		Tons	*Dollars*
Timothy alone	14,686,393	17,985,420	188,082,895
Timothy and clover mixed	19,542,382	24,748,555	257,280,330
Clover alone	2,443,263	3,158,324	29,334,356
Alfalfa	4,707,146	11,859,881	93,103,998
Millet or Hungarian grass	1,117,769	1,546,533	11,145,226
Other tame or cultivated grass	4,218,957	4,166,772	44,408,775
Wild, salt or prairie grasses	17,186,522	18,383,574	91,026,169
Grains cut green	4,324,878	5,367,292	61,686,131
Coarse forage	4,034,432	9,982,305	46,753,262

To understand more clearly just what is included in each class, the following quotation from instruction for clerks in tabulating the Census is given:

(*a*) Tabulate as "clover alone" all crops reported after that designation, as well as all reported as "alsike," "red clover," "crimson clover," also other clovers unmixed with other grasses. The same crops reported as

mixed with timothy or herd's grass should be tabulated as "timothy and clover mixed." When reported as mixed with grasses other than timothy or herd's grass, they should be tabulated as "other tame or cultivated grasses."

(*b*) Tabulate as "other tame or cultivated grasses" all crops reported after that designation, as well as all reported as "redtop," "June-grass," "orchard-grass," "Blue-grass," and "Johnson grass"; also all combinations of these grasses with any of the clover crops mentioned in paragraph *a*, preceding or with timothy.

(*c*) Tabulate as "wild, salt or prairie grasses" all crops reported after that designation, as well as all those reported as "marsh grass," "swamp grass," "slough grass," "bluestem," "daisies" and "buttercups."

(*d*) Tabulate as "grains cut green" all crops reported after that designation without specific names, or with the name "oats," "wheat," "barley," "rye," "peas," "cow peas," "soy beans," "velvet beans," or "vetch." Keep a memorandum of the names of all crops reported with specific names and tabulated as "grains cut green."

(*e*) Tabulate as "coarse forage" all crops reported after that designation without specific names, or with the name "corn," "sweet corn," "cane," "sorghum," "Kaffir corn," "Jerusalem corn," "milo maize" or kindred crops.

Acreage of Forage Crops.—Only about one-fourth of the land of the United States is classed as improved land. Approximately one-half of this is in cultivated crops, mostly cereals and cotton, and one-half in hay and forage (Fig. 123).

The unimproved land includes not only the mountains, deserts, and great range lands, but also some land in farms which has never been plowed or improved, as woodland and marshes. A large proportion of the unimproved land, however, is pastured, and while its pasture value has never been estimated, the aggregate would represent a large figure.

In Chapter I data are given showing the relative value of the hay and forage crops, but no estimate has ever been made of pastures.

Where Forage is Grown.—In the Census of 1909 data were taken on the amount of improved land in hay and forage. A most striking difference is shown between the southern States, where only 5 per cent of the land is in hay or forage, compared with 52 per cent in New England.

New York is similar to New England, and if the pasture land be added, it will be found that in these States 80 to 90 per cent of the improved land is in pasture, hay, and forage.

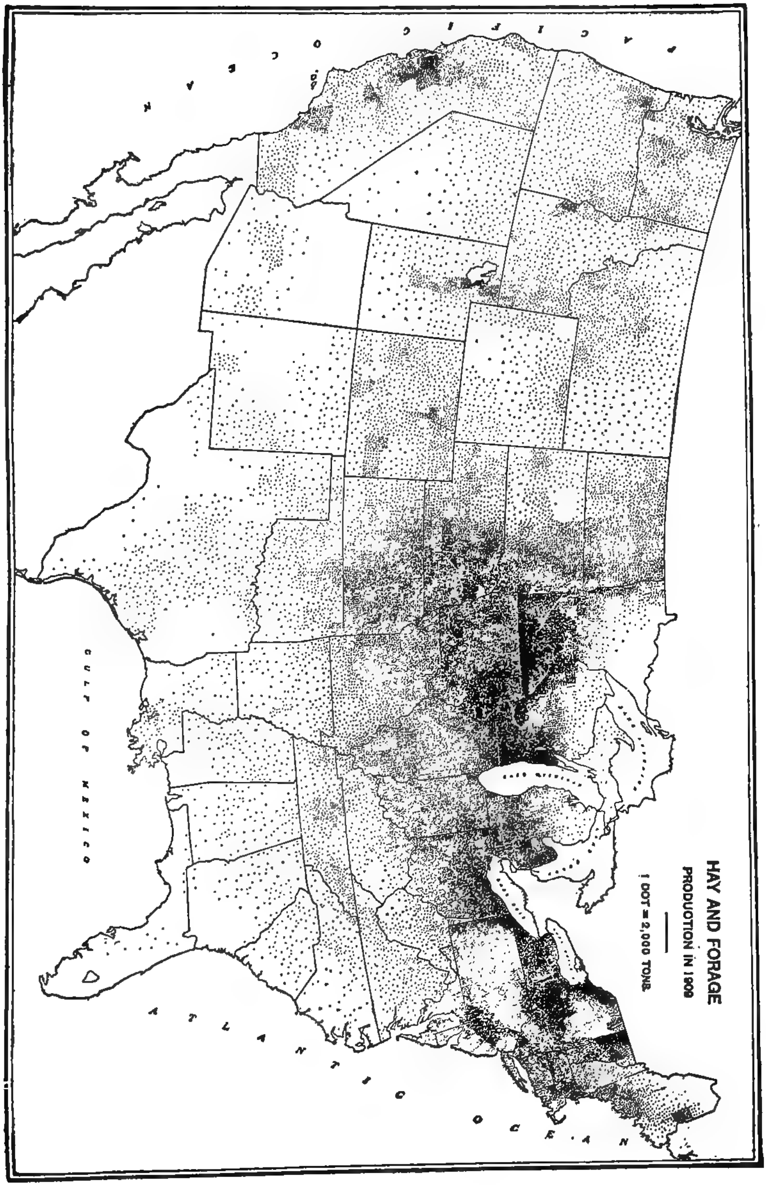

Fig. 123.—Distribution of forage crops in United States. (From U. S. Census Report, 1910.)

Dominant Types of Forage.—The United States can be roughly divided into three great districts, according to the dominant type of cultivated forage.

1. *Timothy–Red clover* region includes all north of the Ohio River and east of the Missouri River. Considerable redtop is grown in New York and New England, and something of all common grasses and clovers, but 90 per cent of the sown meadows are in timothy and red clover, either sown separately or as a mixture.

2. *Cow pea – Bermuda – Johnson grass* region is, in general, south of the Ohio River and westward, including Texas and Oklahoma. Very little timothy or red clover is grown south of Kentucky. While cow peas are extensively planted in this region, very little either of Bermuda or Johnson grass is sown. Both, however, are widely distributed as native plants and come in voluntarily on cultivated fields.

3. *Alfalfa* districts include practically all the land west of the Missouri River where sufficient moisture is available. It is extensively grown in all irrigated districts.

Grain hay, however, is more important than alfalfa in the three Pacific Coast States.

Wild hay is the principal hay in a large district, including the States from Oklahoma northward to Canada, and Minnesota and Iowa.

Blue-grass and *white clover* as pasture plants grow abundantly on all good lands north of Tennessee and Oklahoma. South of this line they both grow well during the winter months, but suffer severely during summer.

Increasing Production.—In all the northeastern States the area in hay and pasture has been steadily increasing since 1860. This is primarily due to two causes: (1) The growth of great cities making a market for hay at profitable prices and the resulting development of the dairy industry to supply cities with milk. (2) The development of the great grain-growing regions in the West made grain growing less profitable in the East, and farmers have turned to the more profitable hay crop.

Yield and Prices of Hay.—The yield of hay is about 1.4 tons per acre for the United States, and only exceeds this average in a marked degree in those States where alfalfa is the dominant hay crop and much of it grown by irrigation. The price is decidedly

highest in the northeastern States. Hay will always be higher here, as it is a bulky crop, and freight is too expensive to ship a great distance.

The price is also high in the South, due to the small local supply, and a large proportion of the hay is shipped in.

Hay Report—Yield, Quality and Price, September 1, 1914

State	Hay (all tame)		
	Yield per acre—10-year average	Production—5-year average	Price Sept. 1—5-year average
	Tons	*Tons*	*Dollars*
New England:			
Maine	1.12	1,299,000	14.02
New Hampshire	1.11	538,000	15.76
Vermont	1.32	1,310,000	13.06
Massachusetts	1.23	582,000	20.28
Rhode Island	1.17	67,000	22.40
Connecticut	1.17	441,000	20.52
Middle Atlantic:			
New York	1.22	5,498,000	14.80
New Jersey	1.34	472,000	17.90
Pennsylvania	1.35	3,840,000	14.98
South Atlantic:			
Delaware	1.37	88,000	14.54
Maryland	1.30	453,000	15.64
Virginia	1.22	793,000	15.56
West Virginia	1.30	770,000	15.20
North Carolina	1.44	375,000	15.90
South Carolina	1.30	219,000	17.46
Georgia	1.50	293,000	17.74
Florida	1.36	52,000	16.82
East North Central:			
Ohio	1.36	3,838,000	12.76
Indiana	1.28	2,194,000	12.44
Illinois	1.25	3,168,000	12.76
Michigan	1.28	3,004,000	13.12
Wisconsin	1.48	3,301,000	12.84
West North Central:			
Minnesota	1.54	2,265,000	8.04
Iowa	1.41	4,511,000	9.32
Missouri	1.14	3,115,000	10.60
North Dakota	1.27	403,000	5.96
South Dakota	1.29	514,000	6.64
Nebraska	1.40	1,591,000	7.86
Kansas	1.30	1,988,000	8.56
East South Central:			
Kentucky	1.25	919,000	14.26
Tennessee	1.42	1,117,000	14.56
Alabama	1.59	268,000	13.66
Mississippi	1.57	275,000	11.58

Hay Report—Yield, Quality and Price, September 1, 1914 (Continued)

State	Hay (all tame)		
	Yield per acre—10-year average	Production—5-year average	Price Sept. 1—5-year average
	Tons	*Tons*	*Dollars*
West South Central:			
Louisiana	1.74	235,000	12.06
Texas	1.41	444,000	10.80
Oklahoma	1.18	388,000	7.96
Arkansas	1.40	363,000	11.30
Mountain:			
Montana	1.80	1,109,000	9.80
Wyoming	2.18	819,000	9.16
Colorado	2.29	1,707,000	9.58
New Mexico	2.35	387,000	11.32
Arizona	3.27	350,000	10.78
Utah	2.89	943,000	8.30
Nevada	2.57	587,000	9.64
Idaho	2.94	1,879,000	7.66
Pacific:			
Washington	2.27	1,620,000	11.90
Oregon	2.11	1,578,000	9.46
California	1.77	4,017,000	10.74
United States	1.40	65,987,000	12.04

QUESTIONS

1. Define the meaning of forage crops.
2. Name the principal classes of forage crops, and state relative importance of each.
3. What is included under the heading " clover "? " Other tame grasses "?
4. What proportion of the United States is classed as improved land?
5. How much in cereals and cultivated crops?
6. How much in hay and pasture?
7. Is the unimproved land utilized?
8. Compare different regions in production of hay and forage.
9. Define the six principal forage regions, as determined by the dominant type of hay plant.
10. Where is hay production increasing? Why?
11. What is the average yield of hay?
12. Give high average yields for States.
13. Where are prices high? State reasons.

CHAPTER XXXIV

CHARACTERISTICS OF ECONOMIC GRASSES AND LEGUMES

THE term "grass" in common usage is sometimes applied to all plants cut for hay, including the clovers and alfalfa. While true grasses do include cereals, as corn and wheat, the clovers should not be considered as grasses. There are other grass-like plants, such as the sedges, found growing in wet meadows, and often cut for hay, that are not true grasses from the botanist's standpoint, but to all practical purposes should be considered with grass.

Number of Cultivated Grasses.—There are in the world some 5000 species of grass, and in the United States about 1400 kinds. However, out of this vast number scarcely 50 have come into cultivation. Of the 50 perhaps not more than 20, excluding cereals and millets, are cultivated enough so that seed is readily obtainable on the market. In fact, there are only about five grasses extensively cultivated, namely, timothy, blue-grass, rye-grass, redtop, and orchard-grass. Of secondary importance are meadow fescue, tall oat-grass, brome-grass, Bermuda grass, and Canada blue-grass.

All of the secondary grasses are important in certain limited areas or for special purposes. A few other grasses are very useful for certain purposes, but the above ten grasses probably represent 99 per cent of the sowings.

Some Important Requirements.—At first it seems remarkable that a bare dozen grasses out of 5000 have attained a place as cultivated grasses. Few grasses, however, fulfil certain essential qualifications, which might be summarized as follows:

1. They must produce seed cheaply. In this respect most of the native grasses fail. For example, the great prairie region of the central States is covered with a dense growth of native grasses. Most of these grasses make excellent pasture and hay, and several attempts have been made to bring some of them into cultivation.

At the Nebraska Experiment Station and other points, during the period 1898 to 1902, more than 200 of these grasses were tested

in small plats. Many of them made a good growth and yielded hay equal to timothy, but they all failed in one respect. They yielded little or no seed that could be easily and cheaply harvested.

The above statement explains why timothy is so popular. It is no better in quality and yield than many other grasses, but produces an abundance of seed at a low cost.

2. Forage grasses should be palatable. There are many wild grasses that produce seed abundantly but are considered to be "weedy" grasses, as they are not very palatable; for example, the American wild rye (*Elymus canadensis*).

3. Grasses must be productive. After elimination of those wild grasses that do not meet the above two conditions we still have left a considerable number of grasses that produce seed well and are palatable to animals, but are not suited to cultivation because unproductive. Sheep fescue and related species are good examples.

4. Grasses must be persistent. There are several good grasses that meet the above three conditions, but lack endurance under pasturage or constant mowing. The large "blue stems" and "blue joint" grasses of the prairies serve as examples. These are dominant grasses on virgin prairie in the Missouri River valley, and very valuable, but are the first grasses to disappear under pasturage or mowing for hay.

A Few Exceptions.—We have a few cultivated grasses that would hardly conform to the above rules yet have so much merit that they are considered valuable grasses.

Bermuda grass is a poor seed producer and is often propagated by spreading the roots. Yet it is so persistent when once established that only a small amount of seed is needed. Also Bermuda succeeds where most grasses fail (in the cotton belt) and therefore has little competition.

Kentucky blue-grass is also a rather shy seed producer, and does not produce a large crop of forage as compared with many grasses. However, it is so persistent when once established, spreading by underground stems, that a small amount of seed will suffice. From 60 to 100 pounds of blue-grass seed are required to sow an acre with a full stand, but if a few pounds be sown with other grasses it will eventually occupy the land. Its ability to withstand hard pasturing

year after year without deteriorating, but often improving, overcomes its rather low yield.

Origin of Forage Grasses.—Out of the 1400 native grasses in America only one has found a place in culture. This is the slender wheat grass (*Agropyron tenerum*) of the western plains. It is adapted to a large area and does well under irrigation.

All the rest of our cultivated grasses have an Old World origin, mostly from Europe. These grasses are found as wild grasses in their native country, but some have practically run wild over the United States since their introduction, as blue-grass and redtop.

The Improvement of Grasses.—Little has been done in developing varieties of forage grasses, most of the cultivated forms being identical with the wild forms. With wheats we probably have 1000 varieties, and 500 varieties of corn, but only one variety of timothy or of blue-grass. Work is now being carried on at several places in developing varieties of grass, and it is likely that in time we shall have commercial varieties of timothy and other grasses, with special adaptation to different soils and climates or suited to special uses, as pasture or hay forms.

CHARACTERISTICS OF GRASSES

The botanists often group wild grasses according to adaptation, as sand binders, marsh grasses, bunch grasses, etc.

Cultivated grasses are sometimes grouped as lawn grasses, pasture grasses, hay grasses, etc. To fully understand the uses of grasses a little study of grass characters is essential.

Grass Roots.—Grasses have fibrous roots in contrast with the legumes that have tap roots. Grasses, on the whole, are considered rather shallow-rooted plants. Where sods have been examined, from 80 to 90 per cent of the roots are usually found in the upper six inches. A few roots usually penetrate to a depth of three to four feet. Smooth brome-grass (*Bromus inermis*) is one of the most heavily rooted of grasses, and usually has a fairly long root system to a depth of five to six feet in the prairie soils.

The age of sod apparently affects the distribution of roots, as they appear to gradually become shallower as the sod gets old and compact. This is illustrated by the well-known weedy quack grass.

Quack (or witch) grass has a heavy, stoloniferous root system, distributed through four to six inches of surface soil in cultivated fields or when first taking possession of the soil. As the sod becomes old and tough the root stocks become shallower, and in an old sod are mostly in the upper two inches.

It is said that one reason why old meadows respond so quickly to fertilizers is due to the rather shallow roots. Old pastures and meadows also are seriously affected by drought, probably for the same reason.

FIG. 124.—Orchard-grass representing a typical bunch grass.

Bunch and Sod Grasses.—Certain of the cultivated grasses, when sown thinly, form compact, isolated bunches which spread very slowly. Orchard-grass and sheep fescue are excellent examples (Fig. 124). Other grasses, as blue-grass and brome-grass, spread rapidly and form tough, compact sods. The principal differ-

ence between these two classes lies in the way the new branches or stems develop.

In *bunch grasses* the new tillers, which usually arise at a node at or below the surface of the soil, grow up *inside* the leaf sheath, as in orchard-grass or tall oat-grass.

In *sod grasses* the tip of the new branch pushes directly through the base of the leaf sheath and spreads a greater or less distance before ascending. There are several forms of this spreading.

1. *Base of stems prostrate,* when the new branch extends horizontally for an inch or two and then bends upward, as in timothy. In some cases new roots may develop at the joints from the prostrate portion of the stem.

2. *Stolons* are branches much further modified, which extend wholly along the surface of the ground. These may produce new roots at any of the nodes, and also erect ascending stems. Buffalo grass is an excellent example. Bermuda grass sometimes produces stolons when the ground is hard, or rhizomes when the ground is soft.

3. *Rhizomes* or root stocks are stems produced underground. They differ from the stolons above ground in the absence of leaves, but are similar in producing roots and ascending stems at the nodes. Blue-grass and brome-grass are good examples.

Adaptation of the Types.—While bunch grasses may make good hay grasses, they are not well adapted to pasture or lawn purposes. The land is badly tramped in wet weather. As plants die from various causes or are tramped out the land is not quickly occupied by the spreading of adjacent plants, but weeds are permitted to come in.

When bunch grasses are sown in pasture, they should be mixed with sod grasses to occupy the vacant spaces.

While some sod grasses grow tall enough for hay, as brome-grass, not all do, but usually make good pasture or lawn grasses.

Certain grasses, however, which normally form bunches when permitted to grow tall, form very compact, close turf when kept close cut, as in a lawn or pasture. Sheep fescue and red fescue are good examples.

Timothy can not be strictly classed with either type. The stems are prostrate for a short distance at the base, forming a slow spread-

ing bunch grass. Sown at ordinary rate of seeding timothy forms a fair sod. Redtop varies a great deal, with a tendency to form stolons, and always forms a good sod.

For convenient reference the common grasses may be grouped as follows, though the line of demarcation is not sharp:

Bunch grasses: Orchard-grass, tall oat-grass, sheep fescue, red fescue, annual rye-grass, meadow fescue.

Semi-bunch grasses: Timothy, perennial rye-grass, wheat-grass.

Sod grasses: Redtop, brome-grass, Bermuda grass, Kentucky blue-grass, Canada blue-grass, bent grass.

Palatability of Grasses.—We say a grass is palatable when cattle eat it readily and appear to thrive. Much chemical study has been made of grasses, but no relation has been found between chemical analysis and palatability. In fact, both the palatable and unpalatable grasses have very much the same chemical analysis.

Generally the better grasses have softer and more pliable leaves and stems, which is about as near a distinction as can be made.

Change in Palatability.—All young grass is palatable and appears to be readily eaten by stock. However, even among young grasses some distinction is noted where the pasture is of mixed grasses. For example, in mixed blue-grass and redtop pasture, cattle usually choose the young blue-grass. If the pasture is all of redtop, however, cattle eat it and thrive.

While all young grass appears to be good, a change is noted as grasses mature. Some grasses retain palatability until well grown, and these usually make good hay, while others rapidly deteriorate in quality after the blossoming period.

For convenience we may roughly group the grasses into two classes, as follows:

1. Grasses that retain quality well after blossoming period: Timothy, brome-grass, wheat-grass, meadow fescue, rye-grasses.

2. Grasses that rapidly lose quality after blossoming period: Orchard-grass, redtop, meadow oat-grass, Kentucky blue-grass, sheep fescue.

However, climate and soil conditions have something to do with retaining quality. In general, grasses retain quality longer on moist soils or in a humid climate than on dry soil or in a dry climate.

The great popularity of timothy is partly due to the fact that hay of good quality can be made for a period of two to three weeks. Some grasses, as orchard-grass, lose quality so quickly after blossoming that the hay must be made in a very short time. As farming operations can not always be adjusted to take care of hay at just the right time, such grasses are usually unpopular.

Adaptation to Wet or Dry Land.—All the cultivated grasses will succeed on well-drained, fertile land and a moderate supply of moisture. However, such land is also well adapted to growing grain and cultivated crops. The wet lands are usually given over to meadow or pasture, while the dry lands are almost wholly given to pasture purposes.

It can not be said that any cultivated grasses or legumes prefer very wet or dry soils, but some are much more tolerant to the extreme conditions than others.

In the following grouping the common legumes have also been included for convenience:

Plants tolerant of very wet soils: Redtop, alsike clover, orchard-grass, annual rye-grass, perennial rye-grass, Canada blue-grass.

Not very tolerant of wet or dry soils: Timothy, meadow fescue, red clover, Kentucky blue-grass.

Tolerant of dry soils: Orchard-grass, smooth brome-grass, alfalfa, sheep fescue, Canada blue-grass.

All the forage plants may be grown in some degree on almost all soils, but some plants have a much greater range than others. For example, orchard-grass, while capable of withstanding wet soil, and even flooding for a week or ten days, is yet capable of growing on dry soils, and is commonly recommended for the dry hills in the Ozark Mountain region and eastward. Redtop, Canada blue-grass, and white clover also have a great range, and might be considered as plants adapted to all conditions.

Other grasses have a much narrower range; for example, the rye-grasses, which always require a rather high degree of moisture, and timothy, which will not do well at either extreme.

Adaptation to Acid or to Limestone Soils.—All the common forage crops will do better on limestone soils, but here again there is a great range in adaptation. Certain plants, as red clover or

alfalfa, will grow only on soils well supplied with lime, at least sufficient lime so they could not be classed as acid soils in any degree. Other plants, as alsike clover and redtop, while favored by at least sufficient lime to give a neutral soil, are yet so tolerant of acid soils that they will grow fairly well under such conditions.

The problem has not been thoroughly worked out, but the plants may be roughly classed as follows:

Tolerant to acid soils: Redtop, alsike clover, orchard-grass, Canada blue-grass, rye-grass.

Moderate lime requirement: Timothy, white clover, meadow fescue, smooth brome-grass, sheep fescue, Kentucky blue-grass.

High lime requirement: Red clover, sweet clover, alfalfa.

Life Period of Forage Plants.—There is no exact way of stating the approximate length of life of a grass. Most of the common grasses under very favorable conditions are long lived, but life is correspondingly decreased as environment is less favorable. For example, some farmers expect a timothy meadow to last only five or six years, yet manuring will double the period of life. In other regions timothy is expected to live ten to twenty years, and there are good timothy meadows on rich, well-watered soils that are known to be fifty years old, and still producing good hay crops.

Length of time for reaching full development or maximum yield will vary, but assuming average conditions we may give the following approximate data:

Average Time Required for Development of Grasses and Legumes

Name	Full development, years	Approximate life of good sod
Red clover	1	Bi-annual
Sweet clover	1	Bi-annual
Alsike clover	1	2–5 years
Rye-grass	1	2 years
Timothy	1–2	5–10 years
Meadow fescue	1–2	3–5 years
Orchard-grass	2	5–10 years
Redtop	2	Fairly permanent
Brome-grass	2	Permanent
Sheep fescue	2	3–5 years
White clover	2–5	Fairly permanent
Alfalfa	3–4	10–20 years
Kentucky blue-grass	3–4	Permanent
Canada blue-grass	3–4	Permanent

Permanent Grasses.—By permanent is meant that under fair environment will continue without deterioration or giving away to weeds. Blue-grass is perhaps the best example. A good blue-grass sod will withstand heavy pasturage for a long period and on good soils will appear even to grow better. This is probably due to the strong underground rhizomes, which constantly produce a new crop of young plants. This is characteristic of brome-grass, redtop, and Canada blue-grass, and apparently of all fairly permanent grasses.

White clover propagates in the same way, but appears to be very sensitive to heat and drought. While it seldom entirely disappears when once established, the white clover will often largely disappear during a period of dry years, to return when rain is abundant.

EXERCISES

Outline for Describing Grasses and Millets.[1]—This outline calls attention to the distinguishing characteristics of each grass.

The stem and leaves:
- Height ....
- Color of stem ....
- Color of leaves ....
- Number of leaves ....

Head:
- Awned or awnless ....
- Panicled, compact, or spiked ....
- Size (give length and diameter) ....
- Color of awns ....
- Color of chaff ....

Root:
- Does it spread from rootstocks? ....
- Is it a sod-forming or bunch grass? ....

Seeds:
- Size (give average length in inches) ....
- Color (general color) ....
- General Notes:
  - Is seed free or inclosed in scales? ....
  - Weight per bushel ....
  - Amount sown per acre ....
  - Vitality ....

Drawings of Seeds.—Make drawing from convex side. Make drawing of cross section.

QUESTIONS

1. Define grasses.
2. How many grasses are there in the world? In the United States? In cultivation?
3. State clearly the essential qualifications of a cultivated grass.

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[1] From the author's "Examining and Grading Grains," published by Ginn & Co.

4. Why is seed production so important?
5. If a grass is a shy seed producer, what compensating qualities must it have?
6. Give the origin of cultivated grasses.
7. Compare the improvement of grasses and cereals.
8. Name some natural groups of grasses.
9. Give the character and distribution of grass roots. Roots in old sod.
10. Clearly define difference between bunch and sod grasses.
11. Define stolons. Rhizomes.
12. To what uses are the types qualified?
13. Does close mowing ever change character of growth?
14. How is timothy classed?
15. Name the principal bunch grasses. Sod grasses.
16. What is palatability? How is it determined?
17. Distinguish between the quality of young grass and full-grown grass.
18. Name some grasses that retain quality when well grown.
19. Is this important in a hay grass? In a pasture grass?
20. Name some grasses that decrease in quality.
21. Why is timothy so popular as a hay grass?
22. Why are grasses often grown on rather extreme types of soil, as very wet or very dry?
23. Why do we say that certain grasses are "tolerant" of wet or dry soil?
24. Name some grasses tolerant to wet soil. To dry soil.
25. What is meant by a wide or narrow range of adaptation?
26. Name plants tolerant to acid soil.
27. Name those requiring soils high in lime.
28. How long may we expect timothy to live?
29. What factors affect length of life in grasses?
30. Name some forage plants that come to full growth quickly.
31. Some that develop slowly.
32. Name some bi-annual plants.
33. Name some long-lived plants.
34. Name some permanent plants.
35. What is meant by permanent?
36. Give the general character of permanent grasses.
37. Is white clover long-lived?

CHAPTER XXXV

GRASS MIXTURES—SEEDS AND SEEDING

For hay meadows it is not the practice to sow grass mixtures in America, though in Europe it is the common custom to sow complicated mixtures. In Europe we hear much about top and bottom grasses, meaning tall grasses, that often do not form a close sod, mixed with shorter, sod-forming grasses that furnish a heavy basal growth of herbage. The bottom grasses are thought not only to increase the yield of forage, but also to provide better pasture and a long-lived meadow.

In the United States out of about 45,000,000 acres of tame grass meadows, about 37,000,000 acres are timothy and clover, about half sown together and half separately. About 4,000,000 are alfalfa, and about the same acreage of "other tame grasses," but how much of the latter are mixtures is not stated.

For pastures and lawns, however, it is more common to sow mixtures, though there are no statistical data on this.

Meadow Mixtures.—The principal reasons for mixing red clover and timothy may be briefly enumerated:

1. Greater yield of forage. Timothy usually does not come to full yield the first year, while the clover does, resulting in a larger total crop. The clover mostly dies at end of first year, but is beneficial to the soil and gives a better second crop of timothy.

2. The roots of red clover penetrate deeper than timothy roots, so the two plants can grow together without directly competing.

3. The feeding value of the hay is greater, as clover is much the richer in protein. In the city markets, however, straight timothy brings a higher price, as it usually has a better appearance, is less dusty and is preferred by liverymen.

One disadvantage in red clover is in ripening about ten days ahead of the timothy. For this reason some prefer the mammoth clover, which ripens approximately with timothy.

Neither orchard-grass nor redtop mixes well with timothy, as they both ripen too soon.

Alfalfa is also impractical for the mixture, as it is usually cut at least three times and timothy only once.

Soil Not Uniform.—One of the principal reasons for mixtures is in cases where the soil in a field is not uniform. In the eastern States the natural supply of lime in the soil is getting so low that certain areas in many fields will not grow red clover, and if there are really acid spots the timothy may fail. As both alsike clover and red-top will grow on more acid soil than red clover and timothy, especially if the land is poorly drained and wet, it is quite common to mix in both of these. Four common mixtures are the following:

On good timothy and red clover soil: Timothy, 15 pounds; red clover, 10 pounds.

Where red clover fails in spots: Timothy, 15 pounds; red clover, 5 pounds; alsike clover, 3 pounds.

Where both timothy and red clover fail in spots: Timothy, 10 pounds; redtop, 5 pounds; red clover, 5 pounds; alsike clover, 3 pounds.

Where both timothy and red clover fail: Redtop, 10 pounds; alsike clover, 5 pounds.

Pasture Mixtures.—The reasons set forth for using mixtures in sowing pastures are:

1. Some grasses are slow in establishing a sod. This is especially true of Kentucky blue-grass, the best of all pasture grasses where it grows well. Three to four years are required for blue-grass to form a good sod, so it is customary to sow some quick-growing grasses with it to furnish pasture while the blue-grass is establishing. It takes from 60 to 100 pounds of blue-grass seed per acre for a full stand, but this is too expensive and it is the general custom to sow only five to ten pounds, and give it more time to spread.

2. Some grasses do not form a good sod and need fillers. This is especially true of orchard-grass or rye-grass, and all bunch grasses. They need some sod-forming grass with them to form a good turf.

3. Succession of plants is important. For example, orchard-grass makes a good growth in early spring and late fall, but poor pasture in midsummer. Blue-grass is at its prime in June, while timothy furnishes good pasturage through July. A mixture will furnish more continuous pasture through a longer season.

4. Soil not uniform. The roughest, most uneven land is usually given over to permanent pasture. In a single pasture, land may

vary from a wet, springy bog to dry, gravelly hill land. Part may be well supplied with lime and part acid. Another part may be under woods and some in the open. No one grass can be expected to succeed in all conditions, while a well-chosen mixture may furnish some good plant for all parts.

Temporary and Permanent Pastures.—A sharp distinction must be made between temporary pastures of one to three years, and permanent pastures. Almost any quick-growing, vigorous grass may produce good temporary pasture. Timothy meadows are sometimes cut for a year or two and then turned into pasture for a year or two. It is not very common practice to sow temporary pastures. Permanent pastures are most commonly on land not well suited to growing cultivated crops. The land is often uneven in quality, and judgment is needed to secure a good covering of pasture plants.

Supplementary Pastures.—Where a supplementary pasture is needed for only one summer or perhaps two or three months, usually one of the cereals, millets or sorghums is used. Winter rye sown early in August will make a late fall and early spring pasture. Winter rye sown in the spring makes a good midsummer and fall pasture. Millets and sorghum may be sown from early spring to midsummer for supplementary pasture. Grasses or clovers are seldom sown for so short a period.

Temporary Pastures.—Frequently a quick pasture is needed for only two or three years. Quick-growing grasses and clovers are used. Rye-grass, timothy, redtop, red clover, and alsike clover are best. These plants, sown early in August, will furnish a good pasturage the following season, and for a period of two or three years. Sown in spring with a nurse crop they will furnish fall pasture the same season.

The following mixture is suggested for temporary pasture. (Seed for one acre.)

English rye-grass	20 pounds
Timothy	5 pounds
Redtop	3 pounds
Red clover	5 pounds
Alsike clover	3 pounds
	36 pounds

This is a heavy seeding, but is desirable where cattle are turned in before time to form a good sod. The amount could be reduced if more time were allowed, or if the soil was favorable for quick growth.

The rye-grass is quick growing but short lived, and will furnish most of the grass the first year, but will be largely replaced with the timothy and redtop the second year. Red clover and alsike are both considered as biennial, and if the pasture is to last more than two years additional seed of these clovers should be scattered on during the spring of the second year.

Permanent Pastures.—There are only five permanent grasses sown extensively in the United States.

Kentucky blue-grass is undoubtedly the most valuable. It is adapted climatically to all the north half of this country and Canada, except acid soils and dry, stony hill lands low in fertility.

Canada blue-grass, while less productive, is excellent in quality, and fortunately will grow on acid soils and on poor, dry soils where Kentucky blue-grass fails. It should be sown where Kentucky blue-grass fails.

Redtop, while as productive as Kentucky blue-grass, is less palatable. It grows, however, on acid or poor soils, where blue-grass fails, and is probably the most important pasture plant in the hill lands of New York and New England.

Brome-grass is capable of enduring dry weather and summer heat, but requires a rather northern climate. In the Dakotas and westward, brome-grass is valuable sown alone and also with blue-grass, as it continues to grow during the midsummer season when blue-grass is dormant.

Bermuda grass is the most valuable permanent pasture grass for the South, below the Kentucky blue-grass and timothy region.

White clover on good soil is regarded as permanent, owing to its ability to produce seed under pasturage, thus constantly reseeding (see Chapter XLII).

Mixtures.—Both of the blue-grasses, white clover, and Bermuda grass are slow in establishing, requiring three to four years. Seed is also expensive and it is the custom to sow thin, depending on their natural ability to spread for a permanent stand. Therefore in sow-

ing permanent pasture quick-growing grasses are mixed with the slow-growing (Fig. 125).

The mixtures here suggested are principally for the blue-grass and timothy region:

1. For soils that will grow blue-grass and timothy:

	Pounds
Timothy	10
Red clover	5
Redtop	5
Orchard-grass	5
Kentucky blue-grass	10
White clover	3
	38

2. On poorer soils, too wet or dry hills low in lime:

	Pounds
Alsike clover	5
Redtop	5
Orchard-grass	5
Canada blue-grass	10–20
White clover	3
	28

1. In the first mixture timothy and red clover will furnish pasture the first two years, but will give way eventually to the other

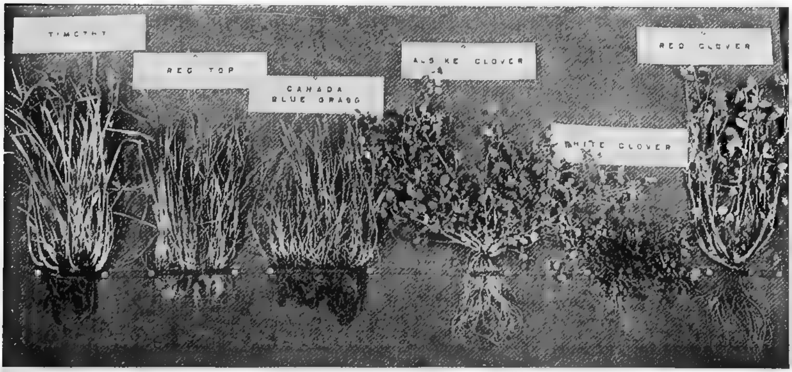

Fig. 125.—Plants used in mixture for pasture on poor land.

grasses. The redtop and orchard-grass will probably persist in the wetter spots and on areas too low in lime for blue-grass. Eventually the blue-grass should dominate, with more or less white clover persistent, depending on the weather.

2. In the second mixture the timothy is left out. Red clover is replaced with alsike, and Kentucky blue-grass with Canadian blue-grass. All these plants, with the exception of alsike, are likely to persist, though the Canada blue-grass and redtop are apt to be dominant in time.

Other Grasses.—Rye-grasses, meadow fescue, meadow fox-tail,

and sheep fescue are all sometimes recommended, but little used in the United States. The rye-grasses are extensively used in Europe, but it is doubtful if they have a place in permanent pasture mixtures in America.

Natural Pastures.—While there are no available data on the subject, it is safe to say that most of the blue-grass pasture has never been sown as such. The wild blue-grass has simply spread by natural means, and taken possession of the land. The same is true of Canadian blue-grass, redtop, and white clover, in regions where these plants are indigenous.

In fact, one test of the permanent pasture value of a grass is to note whether the grass runs wild and if it is persistent enough to run out other vegetation. If it is not capable of this in the region, the plant can scarcely be considered as suited to the hard usage of permanent pasture.

Grass Seeds.—There is very little difficulty experienced in securing reasonably good seed of most standard forage crops. In fact, one of the reasons they are standard crops is because these crops produce good seed cheaply. The most notable exception is blue-grass, which is often not only low in vitality but often high in inert matter, mostly chaff, which is difficult to separate out. Orchard-grass is also often high in inert matter. The points to be observed in judging the quality of seeds may be classed as inert matter, dead seeds, and weed seeds.

Inert Matter.—Grass seeds are usually more or less firmly enclosed in the glumes, and in threshing may be only partly or not at all freed from glumes. This makes the seeds very light in weight, so that small pieces of stem or leaves of about the same size can not be readily separated in the cleaning machinery.

This is illustrated well by redtop, which is often sold "in the chaff" or may be recleaned practically free from the chaff. In the chaff a stroked bushel will weigh about fourteen pounds, but recleaned seed will weigh from thirty to forty pounds. A bushel of redtop seed may weigh anywhere from fourteen to forty pounds, depending on the per cent of chaff present, or seeds that have been freed from chaff. The legal weight and average variation in weight are shown in the following table:

Weights of Seeds of Forage Crops

Name of seed	Legal weight	Variation in weight of one bushel,—pounds
Redtop	14	14–40
Orchard-grass	14	12–22
Kentucky blue-grass	14	6–30
Timothy	45	45–50
Italian rye-grass	20	12–24
Meadow fescue	..	20–30
Smooth brome-grass	..	12–20
Bermuda grass	..	35
Millet	48–50	40–55
Sheep fescue	..	10–30
Peas, beans, alfalfa, clovers and vetches	60	55–65

Seeds Sold by Weight.—Most farm products are sold by the bushel, as grain, potatoes, or apples. Clover, alfalfa, peas, and vetch are also generally sold by the bushel. Timothy is also sold by the bushel, but other grass seeds, owing to the variable weights, are more often sold by the 100 pounds. In fact, it is becoming more common to sell clovers, timothy, and all small forage seeds by the hundredweight, as it is really a fairer and more logical way.

Dead Seeds.—The vitality of new seed properly cared for is usually high. Low vitality is usually due either to poor management in curing or to old seed. Blue-grass offers a good example of seed injured in curing. The seed heads are usually stripped with a machine and piled up to dry. The drying is slow and often some heat develops. It has been proved that blue-grass properly cured has a high vitality.

How long seeds will retain vitality depends largely on storage. In good dry storage most seeds remain vital for two to three years. However, seeds in damp storage or in a warm, humid climate may be worthless after one year.

Immature seeds are sometimes present, especially in the clovers. In clover and alfalfa they usually have a dark brown or shrivelled appearance, and have little or no value.

Hard seeds are common in all the clovers and vetches, but probably do not often occur in grasses. Hard seeds are due to the seed-coat being impervious to water. The seeds will remain in the ground until the seed-coat decays sufficiently so water can enter, which may take one or two years. If the seed-coats are scratched by

rubbing over sand paper they will germinate easily. Soaking in commercial sulfuric acid for thirty minutes will also corrode the seed-coat sufficiently so the seed will absorb water and germinate.

From twenty to fifty percentage hard seed is common in new clover seed, but the hard seeds gradually disappear, so that six to eight months after harvest five to ten per cent hard seeds is about normal. The hard seeds are determined by placing a sample to germinate. All that will grow at once will germinate in six to eight days. The rest that show no signs of decay, but appear to be normal seeds, are counted as hard seeds.

Weed Seeds.—Only a few weeds are considered as really dangerous to introduce. In grasses, Canada thistle and wild carrot are to be watched for. In the clovers and alfalfa the dodders and buckhorn are most dangerous. In general, seed should not be accepted containing any of these weeds.

Germination Tests.—Germination tests are easy to make, by means of apparatus which has been described (p. 18). These tests should be made where large quantities of seed are to be sown and nothing is known about the quality.

Purity, Germination, and Life History of Good Seeds

Name of seed	Reasonable purity	Good germination percentage	Vitality in good storage. Years
Kentucky blue-grass	80	80	1–2
Timothy	97	98	6
Orchard-grass	90	95	2–3
Meadow fescue	97	95	2
Rye-grasses	95	85	2
Brome-grass	98	95	5
Redtop	97	98	6
Millets	99	98	6
Red clover	98	95	6–8
White clover	98	95	2
Alsike clover	98	95	2
Crimson clover	98	95	1–2
Alfalfa	98	95	6–8
Vetches	98	95	3

Actual Value of Seed.—In determining the value of seed it is the custom to first separate out the foreign matter, and then make a germination test of the pure seed. Then multiply the per cent purity by per cent of germination to get an actual rating. For example, a certain sample is 95 per cent pure seed which germinates

90 per cent. Then 95 times 90 equals 85.5, the actual relative value of the seed.

Adulteration of Seeds.—Adulteration of seeds means the addition of some cheaper seed that is so similar that it will not be readily noticed. Thus sweet clover or yellow trefoil may be added to alfalfa or red clover. Several of the grasses are similar enough to permit of intermixing without easy detection. Seeds used as adulterants are often killed by heating, so the deception will not be discovered when the crop is grown. As serious an offence is mixing old seed that has lost vitality with good seed.

Buying Grass Seed.—Grass seeds are graded in the market according to quality. If only first-grade seeds are purchased from reliable seed houses, there will be little danger of either poor quality or adulteration. It is the large demand by the farmers for cheap seed that causes most of the trouble. However, there are occasions when very good seed can be bought cheap, due to presence of some harmless weed or other impurity that may injure appearance but not quality of the seed.

Where Seeds Are Grown.—According to the Census, there were 6,671,348 bushels of grass, clover, and alfalfa seed grown in the United States. The leading States in production were Illinois, Iowa, Minnesota, and Kentucky.

Timothy seed is grown largely in Iowa and Minnesota, though some seed is produced throughout the whole timothy region. Iowa and Minnesota produce about two-thirds of the seed crop.

Redtop is grown principally in southern Illinois.

Kentucky blue-grass is grown principally in the region of Lexington, Kentucky, though it is also grown in both Illinois and Iowa.

Canadian blue-grass comes from the province of Ontario, Canada.

Meadow fescue, produced in northeastern Kansas, Marshall County.

Orchard-grass.—From near Louisville, Kentucky, on both sides of the Ohio River.

Clover Seed.—Separate data for each kind of clover are not given. Three-fourths of the crop was, in 1909, grown by the five adjacent

States, Wisconsin, Michigan, Ohio, Illinois, and Indiana, in the order named.

Alfalfa.—The five leading States, in 1909, were Utah, Kansas, Nebraska, California, and Arizona, in the order named, though some seed was produced in all the western States.

Millets are mostly grown in the Missouri River valley region, Kansas leading in production.

Brome-grass, from the Dakotas and Minnesota.

Imported Seeds.—Considerable quantities of the following seeds are imported: Rye-grass, meadow fescue, brome-grass, alfalfa, and bent grass.

Sowing Grass Crops.—The best and most practical method of sowing grass and clover seeds has largely been worked out as a result of long experience in each locality. In general, grass and clover seeds should not be sown more than an inch deep, and less is preferred if there is sufficient moisture. If necessary, the ground should be well packed before seeding and heavily rolled after seeding to bring the moisture near the surface.

Grass and clovers will germinate at rather low temperatures, endure light frosts, and require rather cool weather and plenty of moisture during first few weeks of growth. They are, therefore, best sown in early spring or early fall, but are likely to fail if sown in summer. This rule, of course, varies with location. In northern latitudes and humid regions, grasses can be sown any growing month, but advancing southward or westward toward the great dry plains region, it becomes more and more important to limit sowing to the cooler portion of the growing season.

Nurse Crops.—The common method of sowing grass or clover seeds in all the northern half of the United States is to show the seed with a grain crop, usually at the time the grain is sown. The grain crop is called a "Nurse crop." The origin of this term is not known, but it probably originated on the theory that the larger crop protects the seeding. This, however, is not exactly the case, as it robs the seeding of moisture and sunlight. In fact, the method is only practical in regions of considerable rainfall and humid climate. West of the Missouri River, where the summers are hot and dry, the

young grass and clover are usually killed by harvest time when sown with a grain crop.

The principal reason why nurse crops are used is because grass and clover sown alone will yield only a small crop the first year, and would mean a partial loss of the land for one season. After harvest the grass and clover usually recover sufficiently to make a full crop the next year. In the case of land infested by weeds it is claimed, with some reason, that a thin seeding of grain will suppress the weeds and will do less harm than full competition with the weeds.

Barley and winter wheat are considered better nurse crops than oats, as they shade the ground less.

Sowing Grass Crops Alone.—West of the Missouri River, where summers are usually both hot and dry, it is getting more common to sow grass, clover, and alfalfa alone, whether sown in the fall or spring.

In the southern States sowing alone is best if spring seeding is practised, but the winters are so mild that all grasses or clovers can be fall sown. In fall seeding it is more practical to sow with fall-sown grain. The fall seeding, however, should be comparatively early to insure strong growth of grass and early harvesting of grain crop.

Sowing in Cultivated Crops.—Whenever there is sufficient late summer rain to put the soil in good condition, it is very practical to sow grass and clover seed in a cultivated crop like corn, in early fall. The greatest objection is the difficulty in smoothing up the land afterward, to make a smooth mowing meadow.

Time of Sowing.—In the northern half of the United States early spring sowing is practised. The most unfavorable time is from June 1 to August 1, when hot, dry weather is likely to occur.

All the common grasses are hardy enough to withstand the winter if fall sown with the winter wheat. The clovers and alfalfa are less hardy and must be sown early, generally not later than August 1 for red clover or August 15 for alfalfa. As it is not practical to sow winter grain so early, the general custom is to sow timothy with the wheat, and clover early the following spring.

Amount of Seed to Sow.—It is the usual custom to sow enough seed of grasses and clovers to insure a full stand when conditions

are unfavorable. No injury results from a very thick stand, while it is not very practical to try to increase a stand that should prove too thin. The quantity of seed used differs locally, but Piper gives the following table as a general guide:

The General Relations Between Number of Seeds Sown and Final Stand

Name of plant	Average rate of seeding to the acre	Number of seeds to the pound	Number of seeds to the square foot	Average number of plants to the square foot for a perfect stand
Red clover	8	250,000	47	15
Crimson clover	15	130,000	45	15
Alsike clover	8	700,000	130	15
Alfalfa	20	200,000	93	15
Sweet clover	25	235,000	140	7
Timothy	15	1,100,000	350	90
Kentucky blue-grass	25	2,400,000	1400	130
Orchard-grass	20	4,500,000	210	90
Brome-grass	20	137,000	65	90
Redtop	10	4,000,000	930	140
Meadow fescue	20	250,000	115	90
Italian rye-grass	30	270,000	215	90
Perennial rye-grass	30	270,000	215	90
Tall rye-grass	40	150,000	140	90

EXERCISES

A STUDY OF THE GERMINATION OF SEEDS [1]

(Prepared by A. T. Wiancko, Purdue University)

Use seeds and boxes provided (see Chapter III). Place a piece of blotting paper in the bottom of each tester or box and have a second piece to cover the seeds. Saturate both pieces of blotting paper. Count 25 kernels each of corn and wheat and place in one of the boxes. Count out the same number each of clover and beans, and place in the second box. Cover these seeds with the second piece of blotting paper. Put on the lid and set aside. Examine every day to note progress of germination and condition of moisture.

1. What is the first act in the process of germination?
2. Which appears first, the radicle (root) or the plumule (leaves)?
3. How many days are required for germination?
4. Is there any difference in the manner in which the cotyledon (seed) is disposed of after germination? Explain.
5. Two modes of root development: *axial*, the radicle extending into a taproot with more or less branches; *diffuse*, no evidence of taproot, but

[1] Reprinted from the author's "Examining and Grading Grains," published by Ginn & Co.

numerous long, slender roots. Which of these seeds show such development? Does this teach anything with regard to soil preparation?

6. Look for the rootcap. What seems to be its office?

7. Observe the root hairs. What do you conclude their function to be? Do they teach anything about soil preparation?

8. Make drawings illustrating different stages of development and showing the various points mentioned above.

9. If possible try the germination under cooler temperature and note results.

DETERMINING THE PURE AND GERMINABLE SEEDS IN A SAMPLE OF CLOVER SEED [1]

(Prepared by A. T. Wiancko, Purdue University)

Take a capsule having one gram of seed in it. Separate this sample into four parts: (1) pure seed that from appearance you judge would grow; (2) pure seed that from appearance you judge would not grow; (3) weed seeds; (4) sticks, chaff, dirt, etc.

Count the seeds in each division. Find what per cent each is of the total number. A pound contains 454.5 grams. Calculate the number of each kind of seeds in a bushel.

Put the seeds in each of the above divisions into a moist chamber and give them the germination test. Calculate the per cent of each division that germinates. How does it compare with the mechanical separation? Calculate what per cent the seeds germinating in classes (1) and (2) are of the total number of seeds. If this seed sells in the market for $8.00 per bushel, what is the actual price per bushel for pure and germinable seed?

A written report is requested one week from the close of the experiment.

Suggested Form for Report

Sample Number	Pure Seed (Good Appearance, Number)	Germination (per cent)	Number per Bushel	Pure Seed (Poor Appearance, Number)	Germination (per cent)	Number per Bushel	Weed Seeds (per cent)	Sticks, Dirt, etc. (per cent)	Total Weight that will grow (per cent)	Actual Cost of this Seed per Bushel
1										
2										
3										

Name.................................... Date.........................

Seeding Machinery.—When grass is sown with grain, it is advisable to have a grass-seed attachment on the grain drill. The grass seed is scattered just ahead of the grain drill shoes or hoes, and is covered up between the rows of grain. It is well to follow with a roller to firm the soil and bring moisture near the surface. For broadcasting the wheelbarrow seeder is probably best, but good results are obtained by hand sowing or using one of the small cyclone seeders of the Cahoon type.

IDENTIFICATION OF CLOVER AND GRASS SEEDS [1]

There is no work which requires more careful attention or is more valuable than the identification of grass and clover seeds, and separating them from their adulterants.

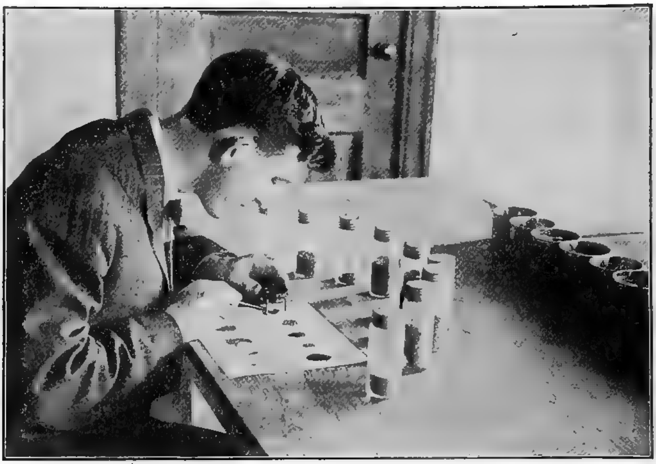

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FIG. 126.—A student identifying clover seed.

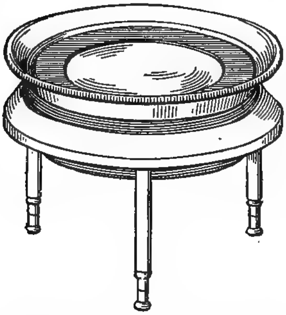

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FIG. 127.—Tripod lens used in identifying seeds.

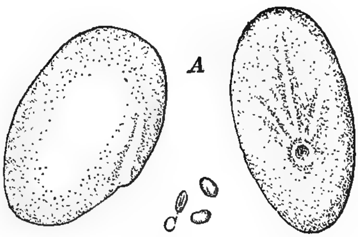
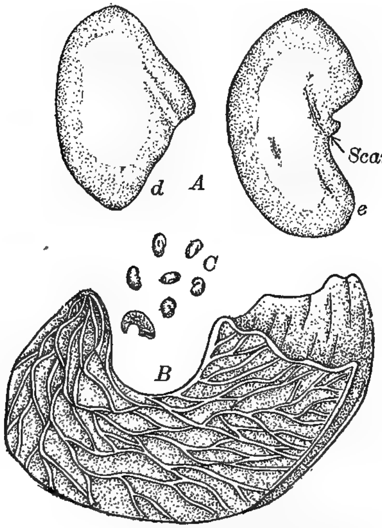


FIG. 128.—Crimson clover: *A*, magnified seeds; *C*, natural size.

For examining the seeds a small tripod lens is very useful. Use the following artificial key, which is not intended to describe the seed but

[1] Exercise from author's "Examining and Grading Grains," published by Ginn & Co.

simply calls attention to the most prominent characteristics of each variety. It is much better to first learn to identify by use of the key than by use of the drawings.



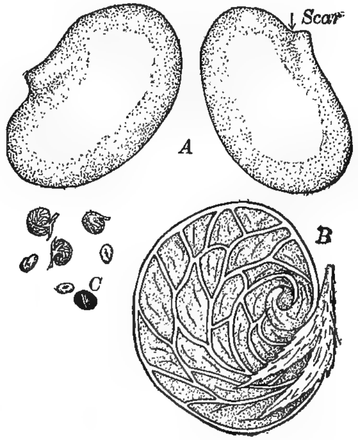


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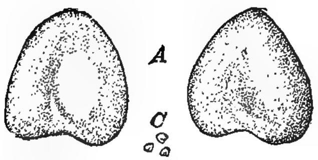
FIG. 129.—Alfalfa: *A*, magnified seeds; *D*, short type; *E*, long, curved type; *B*, magnified pod; *C*, natural size.

FIG. 130.—Yellow trefoil: *A*, magnified seeds· *B*, magnified seed pod; *C*, natural size.



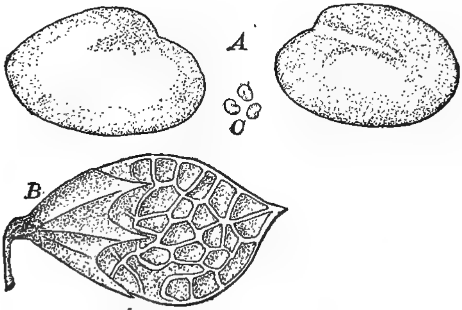


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FIG. 131.—White clover: *A*, magnified seeds; *C*, natural size.

FIG. 132.—Bokhara clover: *A*, magnified seeds; *B*, magnified seed pod; *C*, natural size.

Key for Identification of Clover Seeds

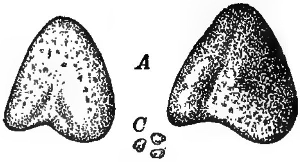
Seed free (not inclosed in pod)

  Seed bean-shaped

    Color, pinkish, $\frac{1}{16}$ inch long ....Crimson Clover

    Color, mostly yellow; large seeds are kidney shaped ......Alfalfa

      (Turkestan alfalfa is same, but slate colored.)



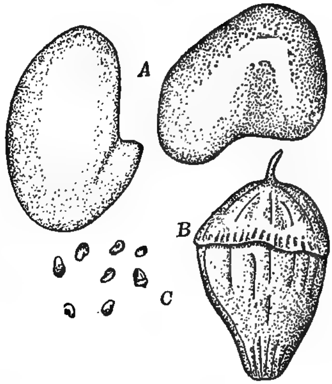


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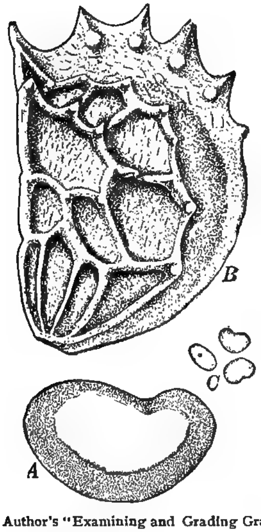
FIG. 133.—Alsike clover: *A*, magnified seeds; *C*, natural size.

FIG. 134.—Red clover: *A*, magnified seeds; *B*, magnified seed pod; *C*, natural size.



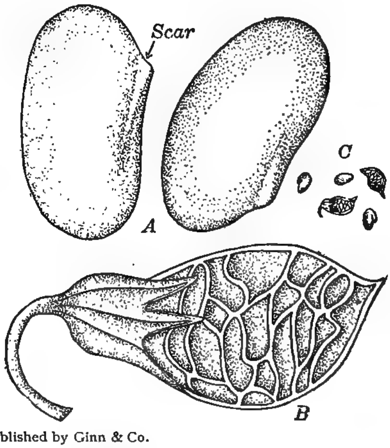


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FIG. 135.—Sainfoin: *A*, magnified seed; *B*, magnified seedpod; *C*, natural size.

FIG. 136.—Sweet clover: *A* , magnified seeds; *B*, magnified seed pod; *C*, natural size.

Seeds larger and more regular than in alfalfa ....Burr Clover
Color, dark yellow to brown......................Yellow Trefoil
Seed oval-oblong
Color, yellow; seed notched near one end..........Bokhara Clover

Seed heart-shaped
    Color, yellow to brown............................White Clover
    Color, dark green to black........................Alsike Clover
Seed somewhat triangular
    Color, yellow to brownish.........................Red Clover
Seed inclosed in pod
  Pod large and corrugated, 1/4 inch long
    Color, brown; seed bean-shaped....................Sainfoin

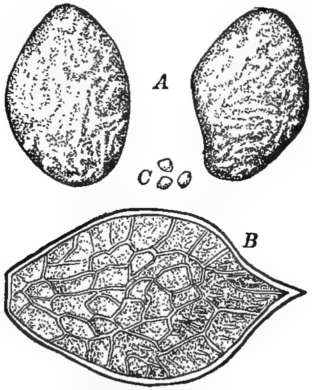

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FIG. 137.—Japan clover: *A*, magnified seeds; *B*, magnified seed pod; *C*, natural size.

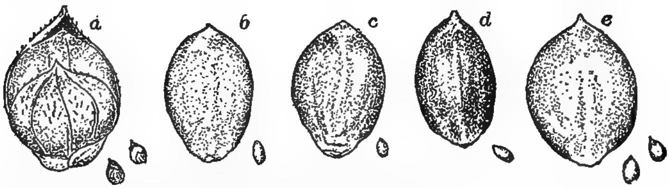

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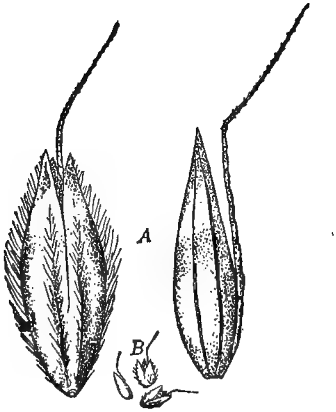
FIG. 138.—Millet seeds: *a*, Japanese millet (Panicum crus-galli); *b*, German millet (Chætochloa italica); Siberian millet (Chætochloa italica); *d*, Hungarian millet (Chætochloa italica); *e*, Broomcorn millet Panicum miliaceum.

  Pod whitish, 1/8 inch long
    Color, yellow; seed oval, notched near end....Yellow Sweet Clover
  Pod brown, 1/8 inch long
    Color, dark brown, seed mottled...................Japan Clover

Key for Identification of Grass Seeds

Seeds distinctly awned
  Seed 1/4 inch or more in length
    Very hairy or pubescent, flat, thin..............Meadow Foxtail
    Awns attached at tip.............................Annual Rye-Grass
    Awns long, twisted, attached near base....Tall Meadow Oat-Grass
  Seeds less than 1/4 inch long
    Small brownish seed..............................Sheep Fescue



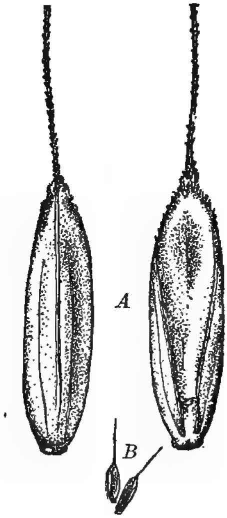


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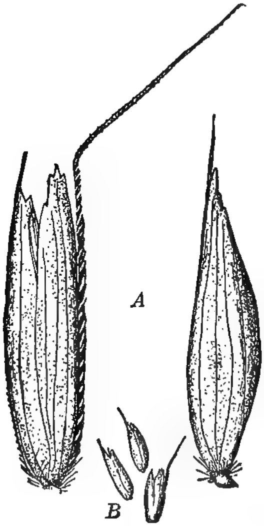
FIG. 139.—Meadow foxtail: *A*, magnified seed; *B*, natural size.

FIG. 140.—Annual rye grass: *A*, magnified seed; *B*, natural size.



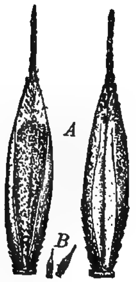


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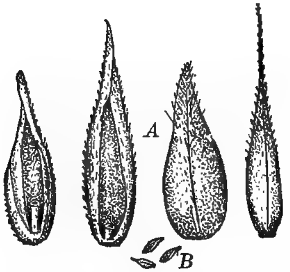
FIG. 141.—Tall meadow oat grass: *A*, magnified seeds; *B*, natural size.

FIG. 142.—Sheep fescue: *A*, magnified seeds; *B*, natural size.

Short-awned or awn-pointed

Small, dark brown seeds, very rough near tip . . . Crested Dog's-Tail
3/8 inch long, smooth, light colored . . . . Wheat-Grass
1/4 inch or less in length . . . . Orchard-Grass



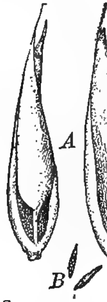


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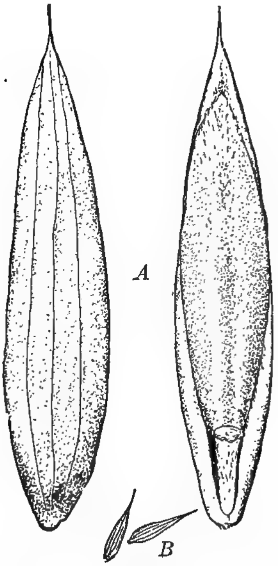
FIG. 143. — Crested dog's tail: *A*, magnified seeds; *B*, natural size.

FIG. 144 — Orchard grass: *A*, magnified seeds; *B*, natural size.



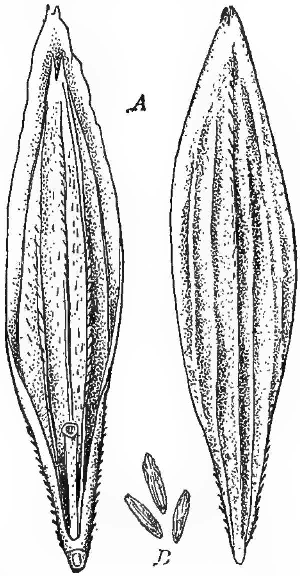


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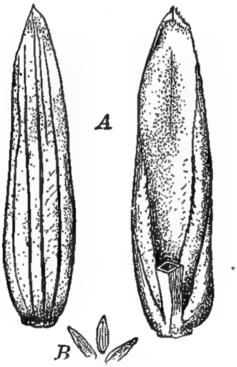
FIG. 145. — Wheat grass: *A*, magnified seeds; *B*, natural size.

FIG. 146. — Brome-grass: *A*, magnified seeds; *B*, natural size.

Awnless

3/8 inch long or thereabouts, nerves very prominent . . . Brome-Grass
About 1/4 inch long, light brown . . . . { Note difference in shape and size of rachilla . . . . } . Perennial Rye-Grass / . . . . . Meadow Fescue

Hard, smooth seeds, about ¼ inch long
    Dark brown color .... Johnson Grass
⅛ inch long or less
    Keel rough, sawlike .... Redtop



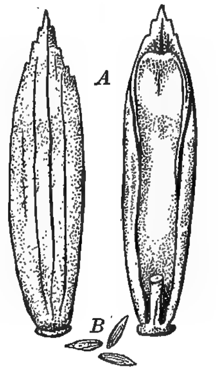


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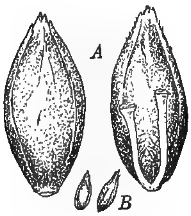
FIG. 147.—Perennial rye grass: *A*, magnified seeds; *B*, natural size.

FIG. 148.—Meadow fescue: *A*, magnified seeds; *B*, natural size.



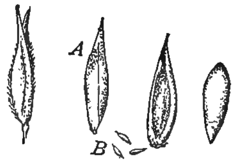


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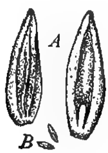
FIG. 149.— Johnson grass: *A*, magnified seeds; *B*, natural size.

FIG. 150.—Redtop: *A*, magnified seeds; *B*, natural size.



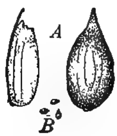


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FIG. 151.—Kentucky blue-grass: *A*, magnified seeds: *B*, natural size.

FIG. 152.—Timothy: *A*, magnified seeds; *B*, natural size.

    Keel not commonly rough .... Kentucky Blue-Grass
Seed free from glumes, polished
    Very small, $\frac{1}{32}$ inch in length, polished .... Timothy

Key for Identification of Millet Seeds

Seeds ovoid, flattened on one side, and inclosed in glumes, usually shiny, from $\frac{1}{10}$ to $\frac{1}{20}$ inch in length
- Seed red or pink................................Siberian Millet
- Seed yellow................................German Millet
- Seed mostly black................................Hungarian Grass
- Seed dull brown, outer coverings loose and rough ....Japanese Barnyard Millet
- Seed brownish yellow (varieties of this millet are white and others red)................................Broomcorn Millet

QUESTIONS

1. What are "bottom" grasses?
2. Compare the use of mixtures in Europe and America.
3. Is there more reason for using mixtures in pastures and lawns than in meadows?
4. Give the main reasons for mixing timothy and red clover.
5. What disadvantages in mixing red clover, redtop and orchard-grass with timothy for hay?
6. How does uniformity of soil play a part in determining whether mixtures should be used or not?
7. Why is redtop and alsike sometimes mixed with timothy and red clover?
8. State clearly the four principal reasons for making mixtures of plants for seeding pastures.
9. Which do you consider the most important reason?
10. Work out a good pasture mixture for your own locality.
11. What general difference should be made in choosing grasses for a temporary pasture and a permanent pasture?
12. What is a supplementary pasture?
13. What plants may be used?
14. Kind of plants suitable for a temporary pasture.
15. Name some of them.
16. Name the five principal permanent grasses, and give the region and conditions under which each should be cultivated.
17. Compare Kentucky and Canada blue-grass.
18. Compare redtop and Kentucky blue-grass.
19. Where is brome-grass grown? Bermuda grass?
20. If blue-grass is the best pasture grass, why do we sow other grasses with it?
21. Study mixtures No. 1 and No. 2 and explain why the changes have been made in No. 2.
22. Name some pasture grasses of secondary importance.
23. How important are natural grasses?
24. Are they common in your own neighborhood?
25. Is ability to run wild a valuable quality?

CHAPTER XXXVI

CARE OF GRASS

After land is laid down to meadow or pasture it is not the general custom to give it much care or treatment. When the meadow is in short rotation and broken up in two years it is advisable to use the manure and fertilizers for the benefit of the grain crops, but if meadows are down three or more years, it is generally profitable to begin fertilizing the second year.

Fertilizers for Grass.—Grass usually responds most profitably to nitrogen, and second to phosphate. Potash is usually plentiful enough in the soil for grass, but its application is very beneficial to clover.

Nitrogen, as pointed out heretofore, stimulates the vegetative growth of plants rather than the development of seeds. Nitrogen then is the most logical fertilizer for grasses. Nitrogen gives vegetation a dark green color, while a lack of nitrogen is indicated by a yellow-green color. This can be easily demonstrated by throwing a handful of sodium nitrate on an old lawn or meadow where the grass is not doing well, and note the change in color in about a week.

While there is usually a supply of nitrogen in soils it seems to become unavailable after a year or two when in sod. This may be due to a lack of air circulation. The point is demonstrated by breaking up an old sod where the grass, by its light green color and poor growth, shows lack of nitrogen. If the land be well prepared and put in corn or grain, there will usually be plenty of nitrogen, as indicated by the dark green color.

Phosphate is deficient in most of the soils east of the Mississippi River that have been under cultivation for fifty years or more. Throughout the corn belt and south, phosphate is probably as important as nitrogen for grass land, but in the northeastern States nitrogen is considered more important.

Potash is an element abundant in soils, but is so insoluble that a small amount of potash is generally profitable on grass land. Potash is especially important for clover. It has frequently been noted in fertilizer trials that the liberal use of potash always gives a much higher percentage of clover in the herbage than when potash is omitted.

Form of Fertilizer.—The form of fertilizer for timothy meadow is very important to consider. It should be soluble, since the fertilizer is applied as a top-dressing. While a less soluble form would be practical to use for cultivated crops where it was plowed in, such forms would not be very valuable as a top-dressing on hay land. For example, cottonseed meal is valuable when plowed into the soil for corn, as it will decay fast enough to become available when the crop needs it. However, cottonseed meal scattered on a hay meadow would do little good, at least during the season applied.

Soluble Fertilizers.—The commonest forms of soluble fertilizing materials suitable for top-dressing meadows are: Sodium nitrate and dried blood for nitrogen; acid phosphate and treated bone for phosphate; muriate of potash and sulfate of potash as a source of potash; potassium nitrate for both potash and nitrogen.

Amount to Apply.—Generally the amount of each ingredient to apply is determined by experience or experiment, rather than by arbitrary rules. Even a soil analysis is very little help. Certain mixtures have been found to generally give good results and it is safer to use these until experience has shown something else to be better.

Sodium nitrate alone at the rate of 100 to 200 pounds per acre is sometimes used. This will usually give a profitable return for a year or two, but as the soil is soon depleted of the minerals the practice can not be continued. In many more cases a combination of sodium nitrate and phosphate is profitable, and on soils well supplied naturally with potash will be found satisfactory for many years. A common application per acre would be:

	Minimum	Maximum
Sodium nitrate	100	200
Acid phosphate	75	150
	175	350

In practice it is best to use the minimum amount at first, but experiment with the larger dosage to see whether the land and crop will respond.

In general, it is best to use a complete fertilizer, not only for the grass crop but to leave the land in best condition for crops to follow. The following formulæ represent typical mixtures for grass land, with the maximum and minimum quantity per acre:

No. 1.

	Minimum pounds	Maximum pounds
Sodium nitrate	100	200
Acid phosphate	75	150
Muriate potash	25	50
	200	400

Composition about 8-6-6. Cost $1.80 per 100 pounds.

No. 2.

	Minimum pounds	Maximum pounds
Sodium nitrate	75	150
Acid phosphate	75	150
Muriate potash	25	50
	175	350

Composition about 7-7-7. Cost $1.70 per 100 pounds.

The amount to use will vary with soils and climate (Fig. 153). Too heavy an application of nitrate will cause a rank growth, easily injured by dry weather. The lower leaves die or "fire," giving a poor quality of hay, decidedly off on color. Generally heavier applications can be made on heavy clay soils than on soils of a sandy nature. Also in dry regions and on dry soils the application should be lighter than on heavy soils or in humid regions. One hundred pounds of nitrate is considered all that is safe to apply on light soils without danger of "firing" the hay in case of a dry season. On heavy, well-watered clay soils 300 pounds can be used, but under average conditions it is seldom practical to use above 200 pounds.

When to Apply.—Soluble fertilizer should not be applied during the fall or winter months, as it may be easily washed away. About one week or two after spring growth starts is considered best. Practically as good results are secured by applying all at one time, as compared with dividing the fertilizer into two or three applications distributed through the growing season.

How to Apply.—It is quite important to make a very even distribution, as it has been pointed out that a double dose may be injurious. A fertilizer spreader is the best tool to use, but a grain drill with fertilizer attachment is satisfactory. When sown by hand, it is best to cross sow, to get evener distribution.

Manure for Grass Land.—Barnyard manure as a top-dressing gives excellent results, and if available at a reasonable cost there would be no occasion to use the commercial fertilizer.

While considerable soluble material is found in the manure, yet it can be put on without great danger of loss during the winter months, unless the ground is too steep.

Reasons for Fertilizing Grass Land.—It is a very common practice for farmers to reserve all manure for cultivated crops, as corn or potatoes. Recent investigations, however, have shown that greater profit can be expected from applying the manure or fertilizer mainly to hay land. Not only is the hay crop largely increased, but the crops following are generally increased as much as though the manure or fertilizer had been reserved for the cultivated crop. This

Fig. 153.—Experimental plots showing growth of timothy on fertilized and unfertilized plots (N. Y. College of Agriculture.)

plan probably would not be practical except where a large proportion of the land is in hay.

Kind of Meadows to Fertilize.—All meadows do not respond well to fertilizer. The principal matters to observe are:

1. That there is a good stand of grass roots. Many old meadows have so little good grass that there is no opportunity for good results.

2. Meadow must naturally be fairly productive (Fig. 154). Generally meadows so poor that they will not yield one ton per acre do not respond profitably to fertilizer. Other faults should probably be corrected first, as acidity, drainage, or humus content.

3. Lime must first be applied to acid soils before fertilizers will give results. This is important throughout much of Ohio, Pennsylvania, and the northeastern States.

Weeds in Meadows.—Certain weeds, such as ox-eye daisy, fleabane, and wild carrot, are serious pests in timothy meadows. In general, however, none of these weeds can compete with grass if conditions are made very favorable for the grass. For example, at Cornell Experiment Station, plats of grass three years old that have received fertilizer or manure are free from weeds, while similar plats unfertilized are usually very weedy. The secret of keeping weeds out is to make conditions right for grass.

Fig. 154.—A productive hay field, the kind that usually responds well to fertilizer. (Photo by Verne Morton.)

QUESTIONS

1. To what fertilizer does grass most readily respond?
2. What effect has nitrogen on vegetation?
3. Is phosphate important?
4. Of what value is potash?
5. What form should fertilizer be in for meadows and why?
6. What is a soluble fertilizer?
7. Name some common fertilizers.
8. Give the approximate amount of fertilizer to apply.
9. When should it be applied?
10. What manure is best for grass land?
11. Compare application of manure or fertilizer to grass land and to cultivated crops.
12. Do all meadows respond to fertilizer?
13. Name conditions of meadow before good results are to be expected.
14. Why does fertilizing or manuring keep down weeds?

CHAPTER XXXVII

THE PRINCIPAL CULTIVATED GRASSES

TIMOTHY

MORE than half of the area sown to cultivated forage crops in the United States is either part or all timothy. Timothy is the dominant cultivated grass in all the region north of the Ohio River and east of the Missouri River (Fig. 155).

Origin and History.—While botanists recognize ten species of timothy, yet only one of these has agricultural value. All but one species of the wild timothies are found growing in Europe, and the cultivated variety is supposed to have been introduced from Europe into the United States. The cultivation of timothy undoubtedly began in the United States. In 1747 it is noted that a man named Herd, of New Hampshire, was cultivating timothy, and some suppose he introduced it from Europe. About the same time it is also noted that Timothy Hansen introduced the grass into Maryland from some point in New England. For many years the grass was known both as timothy and Herd's grass. Timothy is now the common name throughout the world, although it is still sometimes referred to as Herd's grass in New England. This causes some confusion, however, as the name Herd's grass is also applied to redtop in other sections.

Climatic Adaptations.—Timothy requires a rather cool, humid climate, and is quite sensitive to hot, dry weather. It is not adapted to the southern half of the United States, as it will usually summer kill. For this reason very little timothy is found south of the Ohio River, except in the higher elevations along the Appalachian Mountains. Also west of the Missouri River it is likely to be so severely injured by the long midsummer drought that timothy is not highly regarded as a hay crop. We therefore find timothy distributed in the eastern United States about as far south as Kentucky, but in the great plains regions not very much south of the Dakotas; then westward to the coast.

While timothy is so important in the United States, it has never become an important cultivated grass in Europe, probably because their milder winters permit them to grow the rye-grasses which seem to be more popular.

FIG. 155.—Timothy head.

Advantages of Timothy.—The reasons why timothy culture is so popular may be briefly summarized as follows:

1. It produces seed abundantly and at a low cost. This adapts it to use in rotation where the grass must be plowed up occasionally. The seed usually costs not over a dollar an acre and grows very readily.

2. Timothy makes an excellent grade of hay, and has one great advantage over many grasses in that it retains its quality for a period of at least two or three weeks. Orchard-grass, for example, must be cut as soon as it comes to bloom, or it will quickly become woody and poor in quality. Timothy, however, will make a good grade of hay for at least three weeks after bloom. This is a great advantage to the farmer, as he can not always arrange farm work to take care of hay at some particular time.

3. Because of its reliable quality, timothy has come to be the standard hay in the city markets. A higher price is paid for timothy than any other hay.

4. Timothy mixes well with red clover. Most farmers like to grow some red clover when they are using grass in a rotation.

Seed and Seeding.—Very little difficulty is experienced in securing good timothy seed of high vitality. The legal weight of

timothy seed is 45 pounds per bushel, and it should show a germination in five or six days of at least 98 per cent. In good storage, timothy will retain its vitality for five years, but generally seed more than two to three years old is not considered reliable.

Rate of Seeding.—The amount of seed used per acre varies from eight to thirty pounds, while eight pounds per acre will give a good stand if all conditions are favorable, yet in general practice very unfavorable climatic or soil conditions are likely to occur, and farmers have generally found by experience that it is safer to sow fifteen to twenty pounds to be sure of a good stand. Fifteen pounds of seed per acre will give about 350 seeds per square foot. It is generally considered that 100 plants per square foot are necessary for a good stand.

Methods of Seeding.—Perhaps nine-tenths of the timothy sown in the northeastern United States is sown in the fall with winter wheat. It is the general practice to have a grass seeder attachment to the grain drill, which scatters the seed just ahead of the drill. The seed may also be sown after drilling the wheat, but this is not considered good practice, since the seed will then usually lodge in the drill rows and come up with the wheat instead of between the wheat rows. It is generally considered good practice to roll the land after sowing timothy seed in order to firm the soil and bring moisture to the surface.

In many regions where the summers are hot and dry, it has not been found good practice to sow timothy with wheat, as the more vigorous wheat will rob the timothy of moisture, and after harvest the young plants, suddenly exposed to the hot sun, will be destroyed. In such places it is the common practice to sow timothy alone in the fall. If sown about the first part of August, it will make an excellent fall growth, and almost a full crop of grass the next season. This method is also sometimes practised in the South where timothy summer kills. However, before it summer kills a light cutting of grass can easily be secured.

Where fall wheat is not grown, the timothy is most commonly spring sown with either oats or barley. Little difficulty is experienced in securing a good stand in this way, but the plants are not as

strong and usually will not produce as heavy a hay crop the following season as when fall sown with wheat.

In dry regions, the timothy should be sown alone in the spring as well as in the fall.

Lime and Fertilizers.—Timothy does best on a limestone soil, but is not as sensitive to a lack of lime as red clover or alfalfa. However, on a large proportion of the land where timothy is grown in northeastern United States lime has been found to be very beneficial to timothy.

Fertilizing timothy meadows is just now becoming a general practice throughout the timothy belt. In general, timothy gives the greatest response to some form of nitrogen, and, second, to phosphate. It is a general practice to apply the fertilizer as a top dressing in the spring, and for this reason it should be in a very soluble form so that the first rain may dissolve the fertilizer and carry it into the soil. The top dressing is usually applied just after spring growth starts (see Chapter XXXVI).

Where timothy is grown in rotation, it is believed that a greater return for fertilizers or manure can be obtained when applied to timothy than any other crop, with the possible exception of potatoes. Not only is the timothy itself much improved, but it has been found that the grain crop following a timothy sod that has been fertilized is always much larger than after unfertilized timothy, thus giving a double return.

Time to Cut for Hay.—All young grass is very nutritious and highly digestible, and decreases in quality as it matures. However, the total dry weight in timothy increases steadily until the seed has reached the dough stage, after which it usually decreases somewhat in dry weight, probably due to the loss of dead leaves and perhaps the storing of some material in the roots. In general, when both quality and quantity are considered, timothy should be cut for hay when in full bloom. From this time on to the dough stage of the seed it deteriorates slowly, but after the dough stage it loses in quality very rapidly. In general, there is a period of two to three weeks after full bloom when good quality of hay can be secured. The main objection to cutting timothy in full bloom is that there will be more or less pollen dust present, which is sometimes irritating to horses. It is

also a little more difficult to cure at this stage than when cut a week or two later. For these reasons, those who grow hay for market usually cut it rather mature.

Composition and Feeding Value.—Timothy hay is rather low in protein, and would therefore be classed with the feeds suitable for fattening stock or mature animals rather than with the feeds for young growing stock. Generally where timothy has been compared with clover in feeding either young stock or fat stock, it has not given as good returns as clover hay unless considerable nitrogenous feed was used as a balance in the grain ration. However, for horses, it is generally preferred as a hay to red clover, the ration being balanced by the use of nitrogenous concentrates. This is especially true with livery horses in the cities, as clover hay has a rather loosening effect on the bowels. On the farms, generally, a mixture of clover and timothy is preferred to pure timothy.

Yield and Life History.—Timothy is propagated from year to year by means of small bulblets. New bulblets are formed each year about the time timothy is in seed. These bulblets are attached to the base of the old stems. They develop during the fall, live over winter, and produce the new stems and seed stalks the following year. As soon as the plant has produced seed, the old stem and bulblet dies, but meantime a new one is formed for the following year.

Under ordinary conditions, timothy usually produces its maximum crop the second or third year after sowing, after which it is likely to decline more or less. However, this decline seems to depend very largely on available fertility, the application of fertilizers and manure will keep a sod in a highly productive condition for many years. In fact, old timothy sods are known on rich, moist land to remain in productive condition for more than fifty years.

Diseases and Insects.—Timothy smut is more or less common, and in some regions has a decidedly injurious effect on the yield. The extent of its injury is usually not known, since the smutty plants fail to grow large, and their presence would not be observed in a casual examination. Timothy rust occasionally does some harm, but is not considered serious.

Insect enemies do very little harm. The timothy straw worm is probably the most common.

FIG. 156.—Redtop.

REDTOP

The name redtop is generally used for this plant, though it is also known as Herd's grass in southern United States, as fiorin in Europe, and bent grass in England. The true bent grass, however, is really a smaller form, with more stoloniferous habit than the common redtop (Fig. 156).

Origin and History. — Redtop shows great variation in form. The taller species are usually upright in habit of growth, and while they spread from underground roots are not decidedly stoloniferous. Usually the smaller forms are more prostrate in growth and more stoloniferous. The common form of cultivated redtop is native throughout Europe, and was probably introduced to this country. However, one small form, known as "Rhode Island bent," is native to America. Another small, creeping form is the common "creeping bent" grass of Europe. Redtop was first cultivated in Europe, but has been known as a cultivated crop in this country for about one hundred years. It apparently gained recognition much later than timothy.

Climatic Adaptations.—Redtop naturally grows best in a rather moist soil and cool climate, without excessive summer heat. However, it differs from timothy in having a much wider adaptation. It will stand higher summer temperature, much wetter soil, as well as drier soil. Redtop is not considered so good a hay grass as timothy, and therefore can not compete with timothy where the latter succeeds. However, in all the northeastern United States, wherever timothy fails, redtop is likely to be substituted. This is especially true throughout all the hill lands in New York and the New England States, where the soil is too acid for timothy. Redtop will withstand acid soil and is the dominant grass on all these hills. Redtop is also grown to some extent about the southern edge of the timothy belt. It has always been considered as especially adapted to very wet lands, and is commonly sown on wet lands, pastures or meadows. Redtop is extensively grown on the great, flat clay lands of southern Illinois. These lands usually require two or three tons of limestone to the acre to counteract their acidity. These lands are also decidedly wet and in need of drainage. Throughout this area redtop is grown as a hay crop, and practically all of the seed in the United States is produced here.

Life History.—Redtop spreads rather slowly from the root, and usually forms a close, compact sod. It has short root stalks three to six inches in length as a general rule, but individual plants vary a great deal in this respect. Redtop is usually considered as a permanent grass, the root stalks constantly reproducing vigorous new plants that maintain the stand. Its vigorous sod-forming habits make it a grass well adapted for permanent pastures, either alone or mixed with other grasses that need a filler to produce good sod.

Redtop for Pasture and Meadow.—In general, redtop is not considered to be so nutritious or productive as timothy. Its principal merit lies in the fact that it will grow where timothy fails. Redtop pasture is nutritious, but it is generally been observed that where animals had a mixed pasture of redtop and Kentucky blue-grass they are likely to choose the blue-grass in preference to redtop.

Redtop hay of good quality can be secured if cut green enough, but the plant rapidly deteriorates in quality after the blooming period. For this reason it is generally not considered desirable to

mix redtop with timothy, as the market usually discriminates against redtop hay. However, there are large regions where redtop is the principal hay grass, and farmers have learned to cut it fairly green.

Seed and Seeding.—Redtop seed is usually abundant and cheap. It germinates very quickly under favorable conditions in two to three days. Where sown alone, about ten pounds to the acre are used, but in mixtures the quantity is often cut down to as low as two to five pounds. If too much redtop is used in mixtures, its quick, vigorous growth is likely to crowd out other grasses.

In general, redtop is sown in about the same way and at the same time as timothy. The two grasses are grown in the same region and their cultural methods differ very little.

BENT GRASSES

The bent grasses differ from redtop in being much smaller, more prostrate, and with a stoloniferous root system. They have about the same climatic and soil adaptations. Their yield is small, and they are not usually grown for agricultural purposes. However, they make excellent lawn grasses, and are used for this purpose, especially on soil where blue-grass does not succeed. They will withstand more shade than blue-grass and grow on acid soil. They are also especially adapted to sandy soil. The bent grasses will also endure a very close mowing, and are used for putting greens on golf links.

ORCHARD-GRASS

Orchard-grass is in many respects a very excellent grass, but up to the present time it has not received the extensive culture that it probably would if the seed was cheaper (Fig. 157). It costs from four to five times as much to seed an acre with orchard-grass as with timothy or redtop. Also the hay value rapidly deteriorates after blooming period, resulting in a rather poor quality of hay unless care is taken to harvest it at just the right period.

Origin and History.—The cultivated form of orchard-grass is found growing wild throughout Europe and the northern half of Asia. There are several species, all of which have some agricultural value, but the cultivated form, though quite variable, all belongs to one variety.

Orchard-grass had an early introduction into this country, probably about the year 1740. Both timothy and orchard-grass, while of European origin, appear to have received their first extensive cultivation in North America, and were afterwards reintroduced into Europe. Its name is probably derived from the fact that it could be grown in partial shade, and seemed to be adapted to culture in orchards.

Fig. 157.—Orchard-grass.

Climatic and Soil Adaptations.—Orchard-grass is not as hardy in the exterme north as timothy, but can be cultivated with success two or three hundred miles farther south. It will not only withstand hotter and drier summer weather than timothy, but will also endure wetter soils. It is one of the best grasses for river bottom lands, subject to overflow, as it will endure flooding for one to two weeks without injury. Orchard-grass, like redtop, has a somewhat wider adaptation to different soils and climatic conditions than timothy.

Advantages and Disadvantages.—The greater resistance of orchard-grass to summer heat gives it a decided advantage over timothy along the southern edge of the timothy belt. Here it has

come into most general culture. Virginia, Kentucky, and southern Missouri are the regions where it has attained its greatest importance as a forage crop. As a pasture plant, orchard-grass starts spring growth earlier than any other common grass, with the possible exception of smooth brome-grass. Orchard-grass also produces a very heavy aftermath of basal leaves after the seed is harvested. This aftermath continues growth through the fall much later than other grasses. In fact, it continues to grow until hard freezing weather. It thus has an important place in pasture mixtures by furnishing early spring and late fall pasture. Its main disadvantages are the high price of seed, the fact that it forms a rather poor sod, being a decided bunch grass, and also loses in quality as it matures. In pastures it is usually necessary to keep it cropped close or cattle will refuse to eat it when it has gone to seed. If it grows too large, it is generally best to mow the pasture, when the aftermath will come on at once and furnish good pasture the rest of the season.

Seed and Seeding.—The seed of orchard-grass is produced principally in the United States (see page 325) and New Zealand. In general, the quality is fair, but it is likely to contain a rather high per cent of chaff. The ordinary rate of seeding is about twenty pounds per acre. Orchard-grass is not as winter resistant as timothy, and therefore should not be sown in the fall unless sown very early. It is the general custom to sow it in the spring. It may be sown either with a nurse crop, such as oats, or upon fall wheat in February. Orchard-grass seed does not usually feed well through a drill, and must be sown broadcast. The wheelbarrow seeder is probably the best means of sowing it.

Mixtures of Orchard-grass.—As orchard-grass forms a poor sod, it is the general custom to mix other grasses with it for pasture purposes. Redtop and blue-grass are both suitable, as they are good sod-forming grasses. For hay purposes, however, clover is usually mixed with orchard-grass. Another grass which also has been found as a suitable mixture, largely because it matures at the same time, is tall meadow oat-grass. It, however, is also a bunch grass, and when these are sown alone weeds are apt to give much trouble. In the seed-growing regions it has been found very satisfactory to sow about twenty pounds of orchard-grass and ten pounds of red clover.

The seed is harvested by cutting very high with a self-binder, leaving most of the clover uncut. The field is then mowed later, giving a mixture of orchard-grass and clover, which makes satisfactory hay. These fields also furnish excellent pasture late in the fall. Pasturage does not seem to injure the orchard-grass, either for seed or for hay purposes.

In permanent pasture mixtures, usually not more than five pounds of orchard-grass are used per acre. It is a very long lived and persistent grass. The bunches very slowly spread, and on land suited to orchard-grass it will usually come to be dominant in time.

THE BLUE-GRASSES

We have two agricultural grasses known as blue-grass. Kentucky blue-grass (Fig. 158) is the more extensively grown and the more valuable. Canadian blue-grass is much less productive, but will grow on some soils where the Kentucky blue-grass fails. Both are primarily pasture grasses and are very seldom cultivated for hay purposes.

Kentucky Blue-grass—Origin and History.—Kentucky blue-grass, generally known simply as blue-grass, and occasionally as June grass, is of European origin. It was early introduced into this country from Europe, and spread rapidly, especially in the limestone regions. It is now found growing wild through most of North America, except the southern portion. The grass is characteristic of the limestone region in Kentucky, from which it derives the name.

Soil and Climatic Adaptations.—Blue-grass prefers a rather cool, humid climate, and moist, well-watered soil. While its range extends 200 to 300 miles south of the timothy region, it is not well adapted to the Gulf States. During hot, dry weather, blue-grass usually becomes dormant, and the leaves may entirely die and dry up. With the coming of fall rains and cool weather, it quickly revives and will grow well up into the winter.

Blue-grass is decidedly partial to limestone soils. It probably does not require as much lime as red clover or alfalfa, but is not generally considered a valuable grass outside of limestone regions.

Characteristics of Blue-grass.—Blue-grass is a rather fine-stemmed grass, with a strong underground root system. It spreads

Fig. 158.—Kentucky blue-grass on left and Canadian blue-grass on right. Note the crooked stem and smaller head in Canadian blue-grass.

very rapidly by means of rhizomes. It is considered practically a permanent grass. A good blue-grass sod continues to improve for many years, and if given fair treatment, apparently never deteriorates.

Kentucky blue-grass grows very slowly at first, and, even when sown thickly, requires two to three years to make a good sod. In pasture mixtures, usually it takes four or five years before blue-grass is dominant. Blue-grass is so persistent that it will drive out every other grass in the course of time.

Blue-grass is very seldom cut for hay. It is not a heavy yielder of forage, either in hay or pasture, but its other merits offset its low yield to such an extent that it is the most popular pasture grass in the United States.

Seeds and Seeding.—Most of our popular forage grasses are characterized by abundant production of seed of good quality. In this respect blue-grass is an exception, as the seed is always rather high priced, and not of very good quality. Commercial seed will usually not germinate above fifty or sixty per cent, and considerable amount of seed on the market will not show above ten to twenty per cent germination. For this reason great care should be exercised

in the purchase of blue-grass seed. The seed is expensive and would ordinarily cost $10 to $15 an acre for a full seeding. However, the grass is so persistent that if a small quantity of the seed, five or ten pounds per acre, be included in the grass mixture, it will in time completely possess the land. This is the way it is usually sown. Very commonly, when it is expected to turn a timothy meadow into pasture after three or four years, a little blue-grass will be sown with the timothy. In three or four years it will be in marked evidence, and after about two years' pasture, will probably possess the ground.

It is safe to say that probably ninety per cent of the blue-grass pastures have never been sown, but developed voluntarily. Through all the middle western States may be found excellent blue-grass pastures of this character. These pastures were originally wild prairie grasses, but after a time blue-grass began to appear and steadily spread until little else is now to be found in the pastures.

For blue-grass mixtures, see page 308, where the subject is discussed.

Time of Seeding.—When blue-grass spreads naturally, the seed usually falls upon the ground during July and germinates with the first fall rains, or may lie on the ground all winter. Early fall seeding is one of the most favorable times to sow it. Early spring seeding is also satisfactory, as the young grass always grows well during rather cool, moist weather. The most unfavorable time is at the beginning of hot weather in midsummer.

For a full stand of blue-grass, at least fifty pounds to the acre is required, but in ordinary practice five to ten pounds is generally found satisfactory. The lighter seeding will require a year or two longer for the blue-grass to be in full possession, but as it is generally sown with other grasses that provide temporary pasture, this is not considered a disadvantage.

Seed Production.—Blue-grass seed is mostly produced in the north central part of Kentucky, but is harvested in smaller quantities in several other sections, particularly Iowa and northern Missouri. When the seed is ripe, it is usually stripped with machines that tear off the head. The stripped head is then carefully cured. The greatest care is needed in curing, as this material seems to heat very readily and vitality of the seed is quickly destroyed. As threshed,

the seed ordinarily weighs from ten to twenty pounds per bushel, as it contains a large amount of chaff. Carefully recleaned seed will weigh as high as thirty pounds to the bushel. Blue-grass seed is usually sold by the pound, and in all cases the recleaned seed should be preferred, as it contains so much smaller a percentage of hull.

Canadian Blue-grass—Origin and History.—Canada blue-grass is a native of Europe, but had a very early introduction into North America. It seems to be particularly well suited to Canadian climate and soil, especially the province of Ontario. It is found growing wild very generally through Canada and northeastern United States. In adaptation, it differs from Kentucky blue-grass in its ability to grow on poor and dry soil, and also in soils rather low in lime content.

In appearance, Canada blue-grass differs from Kentucky blue-grass in having a flat stem instead of round, in having a much more compact seed head, and a decided bend in stem at each joint, while the Kentucky blue-grass stem is straight. It is also much less productive than the Kentucky blue-grass. Canada blue-grass also is a whitish-green color, while the Kentucky blue-grass is a yellow-green color.

Seed and Seeding.—Canada blue-grass is grown only for pasture purposes, though it is occasionally used for lawns on poor soils. It is a very persistent grass, and five to ten pounds to the acre in a mixture will be sufficient to give a good start. It should not be used where Kentucky blue-grass will grow, but is a very desirable grass for poor soils. The seed is usually abundant and cheaper than Kentucky blue-grass, and for that reason is sometimes used as an adulterant. The seed of the two blue-grasses is so near alike that only a seed expert can tell them apart.

QUESTIONS

1. Give origin and history of timothy.
2. Why is little timothy grown south of the Ohio River?
3. How important is timothy in the United States?
4. Why is it so important?
5. How does the legal weight of timothy seed and keeping qualities compare with other grasses?
6. State the rate of seeding.
7. Give the principal method of seeding timothy.
8. What is the reason for sowing timothy alone?

9. What fertilizers are used on timothy meadows?
10. What is the effect on crop following the timothy?
11. When should timothy be cut for hay? Give reasons.
12. Compare feeding value of timothy and clover.
13. Explain how timothy lives from year to year.
14. How long does it live?
15. State how redtop and bent grasses differ, and in what respects they are similar.
16. When introduced into the United States?
17. Compare redtop and timothy in adaptations.
18. Where is redtop most important?
19. Where is seed grown?
20. Does it form a good sod? Is it long lived?
21. Does it make good pasture? Good hay?
22. When should it be cut for hay?
23. How much seed is sown per acre?
24. Compare redtop and bent grasses.
25. Why is orchard-grass less grown than timothy and redtop?
26. Where did timothy and orchard-grass receive their first culture?
27. Compare the climatic relations of orchard-grass and timothy.
28. Where has orchard-grass advantage over timothy?
29. What are its disadvantages?
30. How is it handled in pastures?
31. What are the best mixtures with orchard-grass for hay? For pasture?
32. What particular merit does orchard-grass have as a pasture plant?
33. How does it compare with timothy for early spring and late fall pasture?
34. Is it a bunch or sod grass?
35. Compare Kentucky blue-grass and Canadian blue-grass in productiveness, appearance, and soil adaptations.
36. Compare blue-grass and timothy as to soil and climatic requirements.
37. Is blue-grass a sod or a bunch grass?
38. Quick or slow in growing? Long or short lived?
39. For what purpose is it best adapted?
40. Is the seed of good quality?
41. State amount required to sow an acre.
42. How important is it as a natural pasture?
43. What is the best time of seeding?
44. Where is the seed crop grown?
45. What is the weight per bushel?
46. Where is Canada blue-grass found most useful?

CHAPTER XXXVIII

THE SECONDARY GRASSES

BROME-GRASS

Brome-grass, also called awnless brome-grass and Russian brome-grass (Fig. 159), is a native of the great upland plains of eastern Europe, notably Hungary and Russia. While it has been cultivated in Europe for perhaps 150 years, it was introduced into the United States only about thirty years ago. It has now attained a place, though not a very important grass, in the western part of the United States.

Characteristics.—Brome-grass is a long-lived, very persistent grass, that spreads by vigorous underground roots. It is very drought-resistant, and therefore adapted to the great, dry plains west of the timothy region. It, however, is a northern grass in climatic relations, and has not given very promising results south of the Dakotas. Through the Dakotas and into Canada, however, it is probably the best cultivated pasture grass. The most valuable quality of brome-grass is its ability to grow and remain succulent during the hot, dry weather of midsummer, when most grasses are dormant or dead. Brome-grass also starts growth very early in the spring, and continues growth late in the fall. One of the principal disadvantages is the tendency to become sod-bound after two or three years. Usually it will not produce seed stalks for more than about two years, but will continue to make good pasture for many seasons.

Seed and Seeding.—Brome-grass yields a good crop of seed of high vitality. The seed grows readily and no difficulty is experienced in securing a good stand. It is the common custom to sow it alone, either in the fall or spring, at the rate of twenty pounds of seed per acre.

A very common custom among the farmers that grow brome-grass is to harvest two or three hay or seed crops, and then turn the brome-grass into pasture for two or three seasons, after which it should be broken up and put into cultivated crops.

Fig. 159.

Fig. 160.

Fig. 159.—Smooth brome-grass.
Fig. 160.—Tall meadow oat-grass.

As brome-grass becomes sod-bound in about two or three years, a number of methods have been tried to overcome this. About the most successful method is to break the brome-grass, very shallow, not over two inches deep. If this is done in early spring, the grass will at once come up and usually produce a seed crop the same year.

TALL MEADOW OAT-GRASS

Origin and History.—Tall meadow oat-grass (Fig. 160) is a native of Europe, where it is very generally included in all mixtures of meadow and pasture grasses. It is very little used in the United States. It seems to be fairly well adapted to the southern States and when better known will probably be cultivated much more than at present.

Climatic Adaptations.—Tall oat-grass is very similar to orchard-grass in its soil and climatic adaptations, except it will not grow on wet soils or in shady places.

Characteristics.—Tall oat-grass is a typical bunch grass, and forms a very loose sod. If sown alone, it should be sown very thickly. It is not well adapted to sow in mixtures, as it is easily crowded out during the first year. For that reason, when grown at all, it is usually grown alone or in some cases mixed with orchard-grass. It is doubtful whether tall oat-grass fills any peculiar place that is not better taken by some other grass.

Seed and Seeding.—The seed is produced at a moderate price, but is rather low in vitality and takes a rather heavy seeding to insure a full stand. Thirty to forty pounds per acre is generally sown. This will probably limit its culture, except where it is found to be superior to other grasses.

MEADOW FESCUE

Origin and History.—Meadow fescue (Fig. 161), also known as English blue-grass, is common throughout Europe and north Asia. There are several varieties, but only two are in commerce, generally known as meadow fescue and tall fescue. There is, however, little difference in appearance. Meadow fescue has been cultivated for about 150 years in Europe, and has from time to time been introduced into the United States, but mostly during the past forty

Fig. 161.

Fig. 162.

Fig. 161.—Meadow fescue or English blue-grass.
Fig. 162.—English rye-grass.

years. It is cultivated principally at present in northeastern Kansas and western Missouri.

Adaptations.—Meadow fescue is, in general, adapted to about the same climatic and soil conditions as timothy. However, in most of the timothy regions it can not compete with timothy as either a hay or pasture grass, and has no especial qualities to recommend it above timothy. In northeastern Kansas it seems to be somewhat more drought-resistant than timothy, and has been found there to produce an excellent crop of seed. It is grown in this region very largely for the seed crop.

Seed and Seeding.—Ordinarily about fifteen to twenty pounds of seed per acre is required. It is generally sown alone, either in the fall or spring, but fall seeding is to be preferred. It should be sown rather early, and will then give a fair crop of either seed or hay the following season.

Meadow fescue is frequently used in grass mixtures for pastures in order to give variety.

Characteristics.—Meadow fescue, when sown thin, has a tendency to form bunches, but will make a fair sod when sown thickly. It does not spread by underground roots. It is considered a long-lived grass, and has shown considerable ability to spread spontaneously, as it is found growing wild through all the northern part of the United States. In hay production it will probably yield about as much as timothy when at its best, but the quality of the hay is not as good.

RYE-GRASSES

There are two rye-grasses, the one known as perennial or English rye-grass (Fig. 162), and the other as Italian or annual rye-grass. They are both rather short-lived perennials, but the Italian rye-grass is less persistent than the English rye-grass. Under average conditions in north Europe, annual rye-grass will live one year, though some plants persist for two years, while the perennial rye-grass will live only two to three years.

Perennial Rye-grass—Origin and History.—It is generally believed that perennial rye-grass was the first grass to be cultivated to any extent. In some places it forms natural meadows and seeds

abundantly, so that seed is easily collected. It has probably been cultivated in Europe for as much as 300 years. It is found growing naturally in temperate Asia and southern Europe. It has been introduced into America about as long as other cultivated grasses, but so far has not attained a place of importance.

Adaptations and Characteristics.—English rye-grass is not adapted either to very cold winters or hot summers, and its culture is limited mostly to regions with a mild winter and humid climate. It seems rather well adapted to wet soils, and it is sometimes recommended in pasture mixtures for wet land. English rye-grass is a very vigorous grower, and will produce a good growth in a short time. For this reason it has been used a great deal in lawn mixtures to sow with blue-grass or bent grass. The rye-grass makes a good growth the first season, but will mostly die out during the next year and give way to the better lawn grasses.

Seed and Seeding.—Perennial rye-grass is sown either in the fall or spring and usually without a nurse crop. Twenty to thirty pounds of seed per acre is required. Seed is not very expensive and usually has a high per cent germination. The seed is practically all produced in Europe and imported to this country.

Italian Rye-grass—Origin and History.—Italian rye-grass or annual rye-grass is found growing wild throughout southern Europe, western Asia and northern Africa. It has been cultivated for at least a hundred years, and has come to be recognized as a very important grass in Europe. It has not gained importance as a cultivated grass in America.

Adaptation and Characteristics.—Italian rye-grass will not withstand cold winters, as it has a strong tendency to be annual, though in mild climates it will live two years. It is a very strong, vigorous grower, and if sown in the spring will make a fair crop of hay the first season. It is well adapted to use in temporary pastures from the Ohio River southward. It will usually live two years when kept closely pastured down.

Seed and Seeding.—The seed is abundantly produced, of good quality, but somewhat more expensive than timothy or redtop. From thirty to forty pounds per acre is required for a full seeding. It is sown either in the fall or in the spring. It is an excellent grass

to sow in the fall with red clover, as they both develop at about the same rate during the following season. It is sometimes used as a crop to mix with crimson clover, and is probably the best hay grass we have for this purpose.

Italian rye-grass is well adapted to grow in wet meadows or under irrigation, where grass is wanted for only one or two seasons. Several cuttings can be made in a season, and under best conditions very large yields are secured.

Italian rye-grass is also used in lawn mixtures as a temporary grass for a year or two, while blue-grass is establishing. It is somewhat shorter lived but a more rapid grower than the English or perennial rye-grass.

BERMUDA GRASS

Bermuda grass is a native of India. It was introduced into this country about the year 1800, and has spread throughout the whole southern half of the United States. It is the most valuable pasture and lawn grass in the cotton belt, taking the place of Kentucky blue-grass in parts of the South. In many places in the South it has long been regarded as a bad weed, but its agricultural value is gaining recognition, and it is frequently sown for agricultural purposes.

Description.—Bermuda grass is a long-lived, persistent perennial that spreads by strong underground root stalks. These root stalks may be the size of a lead-pencil and several feet in length. On hard soil, however, the root stalks may be above ground, as stolons. Sometimes both the above-ground and below-ground root stalks are found on the same plant. The stems arising from the root stalks are usually rather short, varying from four to eight inches on poor soil, or twelve to fifteen inches on good soil. Its seed production is rather low, and it seems to produce seed only in hot, dry weather. The business of collecting the seed for market has not been well developed.

Climate and Soils.—Bermuda grass is adapted to southern climates only. The leaves and stems are easily killed by frost, and the roots below ground are killed in regions where the ground freezes. It ranges as far northward as Washington, D. C., but is not very persistent at that latitude. Bermuda grass will withstand great

summer heat in the bright sun; it will not do well in shade, and succumbs to the first frost.

It is so persistent that it will grow on almost any soil, but of course is much larger and more vigorous on good soil. It is one of the best soil binding grasses known, especially for sandy soils. While well adapted to pasture or lawn purposes, it is often too short for hay.

Culture and Yield.—Seed is rather expensive, and as it is very small, the ground should be thoroughly prepared and well packed before it is sown. About five pounds of seed per acre is required. It should usually be sown alone, as it is easily killed out by shade. The roots of Bermuda grass are so persistent that it can easily be distributed by scattering the sod. The general custom is to break up sods into small pieces and scatter these in furrows about three feet apart. If care is exercised, a cultivated crop can be grown on the same land the first year while the Bermuda grass is getting a start.

When cut for hay, it is cut about three times during the season. The yield is usually not large, the total product of the three cuttings amounting to about a ton or a ton and a half under average conditions.

Mixtures for Bermuda Grass.—Bermuda grass is so persistent that no other forage crop can usually grow with it during the summer months. In some cases, however, the Japanese clover or lespedeza will succeed with it, and greatly increase the summer pasture.

Burr clover is highly recommended to mix with Bermuda grass for pasture. Burr clover grows during the fall and winter months, producing pasture when the Bermuda grass is dead. The burr clover usually reseeds sufficiently so that it is not necessary to resow it each year. It has also been found advisable to sow Italian rye-grass with Bermuda in the fall. This makes an excellent winter pasture, but dies out about the time Bermuda begins to grow the next season.

JOHNSON GRASS

Johnson grass is a large, coarse-growing grass closely related to the sorghums, but differs in being more slender and smaller in size, and in having strong perennial underground root stalks. It was

introduced into South Carolina in 1830, but has since spread by natural means throughout the whole cotton belt. In the past it has generally been regarded as a rather pernicious weed and has very seldom been sown.

Johnson grass is regarded as a perennial about as far north as Virginia, but winter kills wherever the ground freezes severely. Johnson grass is very drought-resistant and is so persistent that it will succeed in almost any soil.

Culture.—Johnson grass is usually sown at the rate of fifteen to twenty pounds per acre. It produces a rather large yield for two or three years, after which it becomes sod bound, probably due to the large growth of underground roots. It will then make very good pasture, but not growth enough for hay. The sod can be very easily renewed by plowing up, after which the grass will quickly come up and be as vigorous as it was before. In renewing Johnson grass it is also a good practice to fall plow the land and sow to winter oats. After the winter oats have been harvested, the Johnson grass will again take possession of the land. In the South two to three cuttings a season can be made. The yield varies from one to two tons at each cutting.

It is almost impossible to eradicate Johnson grass when once established, and it should not be sown where it is not desired to keep it permanently or in rotation with a winter grain crop, such as oats. However, where it is well established, it will pay to take care of it, as Johnson grass is a valuable hay and pasture plant for the southern States.

SOUDAN GRASS

Soudan grass is very similar to Johnson grass, except that it is an annual and without strong underground root stalks. It can be sown anywhere without fear of infesting the land. Soudan grass was recently introduced from Africa by the United States Department of Agriculture. It is believed to be the wild form of cultivated sorghum, with which it crosses very readily. It differs from sorghum in being fine-stemmed and in stooling very freely, so that from twenty to fifty stems may come from a single seed.

Soudan grass, like millet, makes a very quick growth in hot

weather and produces a somewhat better quality of hay. It is very drought-resistant and adapted to the same general region as the millets and sorghum, and will also probably find a very extensive culture throughout the Southern States. Soudan grass is two or three weeks earlier in maturing than the sorghums and therefore can be cultivated much farther north, but it is not as early as some varieties of fox-tail millet. It has the quality of springing up quickly from the roots when cut, and will produce from two to three cuttings in the southern States. For hay purposes it may be broadcasted or drilled at the rate of thirty pounds per acre, or half this amount, if grown principally for the seed. Soudan grass may also be cultivated in rows, spacing the rows twenty-five or thirty inches apart and giving clean culture. Only three to five pounds per acre of seed are required for planting in rows. Soudan grass produces seed in abundance, and, it is believed, will soon occupy an important place as a forage crop.

QUESTIONS

1. Give the origin of brome-grass.
2. Where is it cultivated in the United States?
3. Describe brome-grass as to life period, root system and climatic adaptations.
4. What do you consider its most valuable qualities?
5. What is meant by "sod bound"?
6. How is this difficulty overcome?
7. Is seed cheap and easy to grow?
8. Where is tall meadow oat-grass grown?
9. To what other grass is it similar?
10. Describe its characteristics.
11. What amount of seed is used per acre?
12. Relate the origin and history of meadow fescue.
13. Compare it with timothy as a forage crop.
14. Where is it grown?
15. State amount of seed sown per acre.
16. Name the characteristics of meadow fescue.
17. Name and compare the two principal rye-grasses.
18. How long has perennial rye-grass been grown?
19. Describe its climatic adaptations. Soil adaptations.
20. What quantity of seed is sown per acre?
21. How important is Italian rye-grass?
22. Describe it as to length of life, cold resistance, vigor of growth.
23. Is seed expensive or cheap?
24. Explain the principal uses for rye-grass.
25. Give the origin and introduction of Bermuda grass.
26. Name region where best adapted.
27. Describe Bermuda grass as to its root system, persistence, height and other important characters.
28. State its natural range northward.
29. Adaptation to sun and shade. Adaptation to soil.

30. How is a stand of Bermuda grass secured?
31. With what plants is it mixed for pasture purposes?
32. Describe Johnson grass.
33. To what region is it best adapted?
34. Is it persistent?
35. What are its principal uses?
36. How is a stand secured?
37. State objections to Johnson grass.
38. How may it be rotated with oats?
39. Compare Johnson grass and Soudan grass.
40. Name region where Soudan grass is best suited for cultivation.
41. Give methods of culture.
42. Why do we expect its culture to increase?

CHAPTER XXXIX

MILLETS

The name millet is applied to a considerable variety of plants, such as cultivated forms of fox-tail grasses, barnyard grass, while in India the common varieties of sorghum are known as giant millets. Practically all the millets, however, are coarse-growing annual grasses, bearing a large, compact seed head (Fig. 163). The culture of millets is very ancient, probably as early as the culture of wheat. Millets are especially adapted to primitive agriculture, as they can be grown with little or no preparation of the soil, and show some tendency to run wild where they do well, while the seed heads are easily harvested and prepared for feed. Up to quite recent time, it is probable that the millets, including sorghum, formed the most important source of cereal food for mankind, but in most countries millet seeds have been replaced by rice and wheat as human food. Millet and sorghum seeds, however, are still very extensively used in India, China, and North Africa.

Distribution.—In the United States the millets have been used principally as forage crops. The culture of millet as a forage crop is most extensive in the upper part of the great plains, from Dakota to Kansas, while from Kansas southward sorghum largely takes the place of millet as an annual forage crop.

The development of these two annual forage crops in the great plains is probably due to the fact that the standard hay crops of the East, timothy and clover, do very poorly in the great plains. In the past, prairie hay was the principal hay grass of the great plains. As the prairies have been broken up, alfalfa has become the principal perennial forage, but it is rather expensive to secure a stand of alfalfa and it is only adapted to long rotation systems, so considerable place has been found in this region for an annual forage crop like millet and sorghum.

Kinds of Millet.—In the United States the name millet is applied to four very distinct types of annual grass: (1) fox-tail millet; (2) broom-corn millet; (3) barnyard millet; and (4) pearl millet.

Fox-tail millet is the most important group, and constitutes prob-

ably 90 per cent of the acreage sown (Fig. 164). The fox-tail millets are all supposed to be derived from the wild, weedy grass known as green fox-tail. However, under cultivation a great many types and varieties have been developed. Practically every gradation is to be found between the different types, but for convenience they are usually classed into four groups, as follows:

FIG. 163.—Millet plants.

1. *Hungarian Grass or Hungarian Millet.*—This is a rather early form, maturing in sixty to eighty days. The heads are rather small, usually well covered with bristles. The seeds vary from yellow to black, and both colors are found in the same head. The stems are usually fine and the plant comparatively leafy. Hungarian grass is considered quite drought-resistant, and is probably better adapted to soils of medium or low fertility than the other millets. It averages about twenty-five to thirty inches in height. Hungarian grass also runs wild very easily, and this is sometimes heard as an objection to its culture.

2. *Common millet* is a name applied to several varieties of millet somewhat taller than Hungarian grass, maturing at about the same time, and with seeds all of a light yellow color. The head is comparatively slender, and when well developed usually droops.

3. *Siberian millet* is quite similar to the foregoing varieties, but the seeds are a bright orange color.

4. *German millet* is much taller and coarser growing and two to three weeks later than common millet (Fig. 165). The heads are large and rather loose. The seeds are yellow, but slightly smaller

than the seeds of common millet. German millet requires a richer soil for full development than the other millets.

Culture.—Millets are hot-weather plants and are rather slow in starting if sown early in the spring. There is danger of weeds overcoming early-sown millet. Seeding may take place anywhere from two weeks after corn planting up to within sixty to eighty days of frost. For this reason millet is very frequently used as a catch crop, where some early-sown crop has failed. From Kansas southward millet may be sown after wheat harvest, and if fall rains come early enough a fair crop will develop.

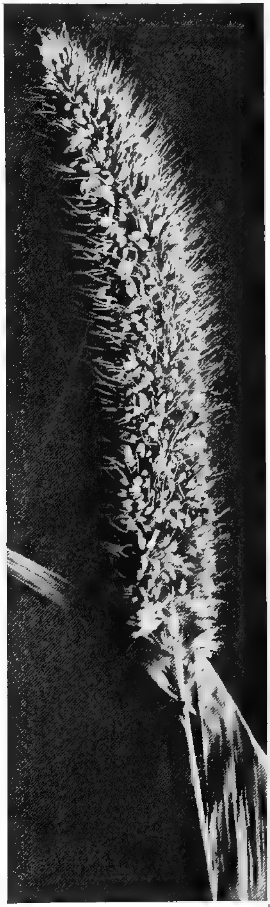

Fig. 164.—Common millet.

Millet is quite commonly believed to be hard on the land. At any rate, it is sometimes observed that small grains following millet are less productive than on adjacent lands where other crops have been grown. Ordinarily this effect is not so noticeable in a cultivated crop like corn. After a year or two, the effect seems to disappear. No one has given an adequate explanation of this phenomenon. It is not believed that millet actually takes more plant food from the soil, but as it is a very vigorous growing, shallow-rooted plant, it is thought by some to more thoroughly exhaust the available supply in the upper layers than most of the common crops. The theory has also been advanced that it may leave some toxic substance in the soil, but this has never been demonstrated. At any rate, the injurious effect is usually small and temporary, and seldom deters farmers from sowing the crop.

Rate of Sowing.—For a hay crop, from thirty to sixty pounds of seed are sown per acre, and for a seed crop about half of this

amount. Usually the thinner seeding is put on heavy, fertile soil.

Feeding Value.—Millet is very easily cured into hay of good quality. Millet hay has a loosening effect on the digestive tract of horses, and also when horses are heavily fed with it for a long time without change it is very apt to cause slight swelling and inflammation of the joints. Where fed only part time, or mixed with other roughage, it is not thought to be injurious. Millet is not reported as injurious to cattle or sheep.

Japanese barnyard millet (Fig. 166) is also known as "Ankee" grass in India. It is closely related to the common barnyard grass found everywhere in North America, but the cultivated form is somewhat more erect and was brought to this country from Japan.

Adaptations.—Barnyard millet is especially adapted to culture on wet lands. The wild form is found growing very rank along the irrigation districts in the western States, while on lowlands, subject to overflow, wild barnyard grass is often found growing to the exclusion of almost all other vegetation. It is not suited to cultivation in dry or unproductive soils.

The hay is rather coarse and not of first quality, but no injurious effect has ever been reported from feeding it. One to two pecks of seed are sown per acre and should not be sown till warm weather has arrived. An average yield is two to three tons per acre, but on rich, wet lands yields of four to six tons are sometimes harvested.

Broom-corn millet is so called from its rather loose, spreading head. This is the true millet of Europe and Asia, and is very extensively grown for human food in India. Under average conditions it is less productive of forage, but probably a heavier seed producer than other millets.

In North America it is best adapted to the northern part of the great plains, especially at the higher elevations in Montana and the western part of the Dakotas. It seldom does well from Nebraska southward. Broom-corn millet is usually sown at the rate of two to four pecks per acre.

Pearl millet, also called penicillaria, is not at all like the other millets in appearance or habit of growth. It is a tall, coarse-growing plant, reaching a height of ten to twelve feet. Usually it stools a great deal, producing up to ten or twelve stems from a single seed.

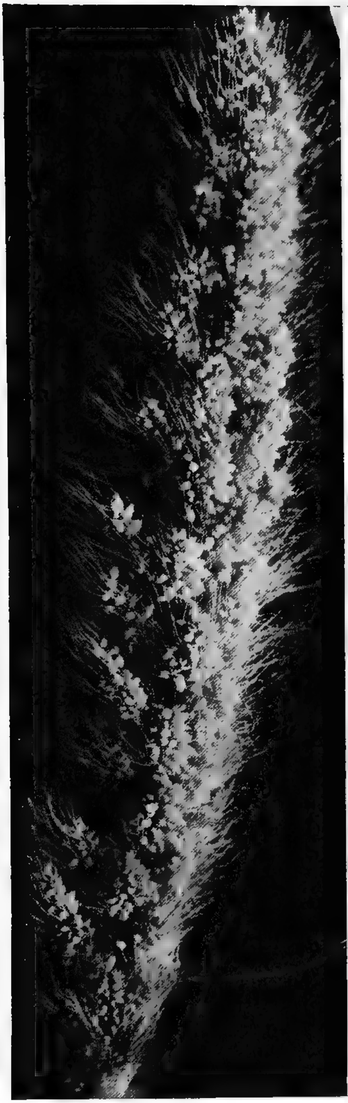

Fig. 165.—German millet.
Fig. 166.—Japanese millet.

Pearl millet matures as far north as South Dakota. When cut down it springs up readily from the roots, and in the southern States may be cut two to three times a season. While it makes a very large yield, the forage is of little value, as it is too coarse and woody to feed animals as a regular ration.

QUESTIONS

1. What kind of plants are included under the name millet?
2. How important have millets been in the past?
3. How important are they at present?
4. Give the principal uses of millet.
5. Where are they grown in the United States?
6. Why has millet and sorghum culture developed in this region?
7. Name the four different kinds of millet.
8. Describe and compare the four principal kinds of fox-tail millet.
9. Describe the culture of millet.
10. Give effect of millet on productivity of the soil.
11. What is the explanation for this effect?
12. Give the feeding value of millets.
13. Describe Japanese barnyard millet.
14. Give its soil adaptations. Quality of the hay.
15. Describe broom-corn millet. Where is it grown?
16. Describe pearl millet.

CHAPTER XL

LEGUMES

THE botanical family, Leguminosæ, comprises some 10,000 species. The distinguishing feature is that the seeds are borne in a pod or legume. The family as a whole is mostly found in the tropics, but at least some species are found in practically all parts of the globe where plants grow. About one-fourth of the Leguminosæ are large trees, such as the honey locust or coffee tree. The rest are shrubs or herbaceous plants.

The family is divided into three groups, one of which is known as the *Papilionaceæ* or pea family. The Latin name comes from *papilio,* meaning a butterfly, because the flowers somewhat resemble a butterfly in appearance. Practically all the legumes grown for forage belong to this group, and most of the legumes discussed in agricultural literature belong to the pea family. In some cases, as the clovers, the legume or pod is so modified that it would hardly be recognized as related to peas, but the flowers of practically all the pea family are similar and easily recognized. The principal genera of legumes cultivated as forage crops are the following twelve:

1. **Trifolium or Clover Group.**—There are in the world about 250 species in the clover family, sixty-five found in North America. Hunt [1] names thirty species which have at least been tested experimentally. Only a half-dozen have attained importance.

Trifolium pratense, medium red clover.
Trifolium perenne, mammoth red clover.
Trifolium hybridum, alsike clover.
Trifolium repens, white clover.
Trifolium incarnatum, crimson clover.
Trifolium Alexandrium, berseem.

2. **Medicago or Alfalfa Group.**—There are some fifty species in this family, several sown for forage, and several others, as the burr clovers, that have considerable value as wild plants.

[1] "Forage and Fiber Crops," p. 140.

Medicago sativa, common alfalfa.

Medicago media, sand lucern.

Medica fulcata, yellow or sickle alfalfa.

Medicago denticulata, burr clover (several species).

Medicago lupulina, black medic.

3. **Phaseolus, or Bean Group.**—This group contains a number of species, the most important being the common field bean and lima bean. The field beans, however, are classed as kidney, marrow, medium, and pea beans, according to shape and size of seed.

Phaseolus vulgaris, common kidney bean.

Phaseolus angularis, adzuki bean.

Phaseolus aureus, mung bean.

4. **Pisum arvense, or pea group,** is sometimes divided into field peas and garden peas, though the real difference between the two is slight.

5. **Vigna sinensis,** or cow peas.

6. **Soja max** (old name Glycine soja), or soy bean family.

7. **Vicia, or vetches,** include cultivated species and many wild forms.

Vicia sativa, tares or common spring vetch.

Vicia villosa, sand or hairy vetch.

Vicia faba, horse bean or Windsor bean.

8. **Melilotus, or Sweet Clover.**—Several species have agricultural value, but only three are generally known.

Melilotus alba, white sweet clover.

Melilotus officinalis, large yellow sweet clover.

Melilotus indica, small yellow annual.

9. **Lespedeza striata,** or Japan clover.

10. **Desmodium tortuosum,** or Florida beggar weed. Several similar wild species widely distributed.

11. **Stizolobiun deeringiarrum,** or Florida velvet bean.

12. **Lupinus,** including several species, as **albus, luteus,** and **angustifolius.**

There are several other families of legumes that have a certain agricultural value, but do not as yet have regular cultivation.

COMPARISON OF LEGUMES AND GRASSES

Roots.—It is frequently stated that legumes are deeper-rooted plants than the grasses. It is a difficult point to determine, as it is not a simple matter to separate roots from the soil to a depth of several feet. The character of the soil, age of plants, and other factors so modify the depth and distribution of roots that data taken at different places or at various times are not comparable.

Data on depth and amount of roots have been taken at Connecticut, Utah, Arkansas, North Dakota, Kansas, Minnesota, and other places. In general, with both grasses and clovers, from eighty-five to ninety per cent of the roots bv weight have been found in the upper six inches. Alfalfa should be excepted, as it is a very deep-rooted plant. Red clover is also a strong-rooted plant, penetrating from four to six feet, while white clover is believed to root about one-half as deeply.

Grasses also vary, brome-grass and orchard-grass penetrating five to six feet in pervious soils; timothy generally three to four feet, blue-grass usually less than three feet. Soils also have a marked effect, the quantity of root being much greater in the subsoil when loose soils are compared with hard, impervious soils.

Timothy and red clover are very generally grown in mixture, and it is probably true in this case that the red clover has a more abundant root system below the upper twelve inches than the timothy. There is also evidence that as grass sods get old and well matted the roots become quite shallow (see p. 296), while in the case of long-lived legumes the deep tap roots probably increase in size.

The total amount of root material is of interest as indicating the residue of organic matter left in the soil. Data on red clover and alfalfa, taken at various places, have shown variations ranging from 1000 to 5000 pounds per acre, with most cases nearer the lower figure. The proportion of root to top is usually about 1: 1.5 or 1: 2. The data, however, can not be considered very reliable or constant.

Composition of Legumes and Grasses.—The following table of certain analyses gives a general idea of the relative composition of both the forage and seeds of legume and grass crops:

Crop	Water	Ash	Protein	Crude fiber	Nitrogen-free extract	Fat
Forage:		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Timothy hay.	13.2	4.4	5.9	29	45.	2.5
Alfalfa hay...	8.4	*7.4*	*14.3*	25	42.7	2.2
Grain:						
Maize.......	10.9	1.5	10.5	2.1	*69.6*	5.4
Beans.......	15.0	3.1	*20.4*	3.2	56.7	1.6
Soy beans...	10.8	4.7	*34.0*	4.8	28.8	*16.9*

The legume forage and seeds are very high in protein content. The seeds of grass plants (maize) are high in starch. Certain legumes store considerable oil, as illustrated by the soy bean. The seed of grasses has a large endosperm, usually rich in starch, and a small embryo, while in legume seeds there is no endosperm, but the seed is filled with embryo. The composition of legume seeds is about the same as that of the embryo of grass seeds.

Effect of Legumes and Grass on Fertility of Soil.—It has already been pointed out in Chapter V, on Rotation of Crops, that both grass and legumes, in a rotation with grain crops, help to maintain productivity as compared with grain alone. Rotation, however, is not a permanent means of restoring productivity, as both grass and legumes exhaust the mineral supplies of the soil. In one important respect they differ, and that is the effect on nitrogen supply of the soil. Legumes acquire free nitrogen from the air, and it is fair to suppose that they do not exhaust this element, the most costly of all, from the soil.

The principal method of determining this point in field tests is to grow crops of legumes and make occasional soils analysis, or to grow legumes, alternating with grain crops, noting the general vigor and appearance of the crops. In certain rotation experiments, where red clover has been grown one year in three or four, the nitrogen supply of the soil has been maintained, although the grain crops would remove large amounts.

One way of comparing the relative exhaustive effect of legumes and grasses is to evaluate the important fertilizing constituents.

Value of Nitrogen, Phosphate, and Potash in One Ton of Timothy Compared With One Ton of Clover

Crop	Nitrogen	Phosphoric acid	Potash	Total value
Timothy:				
Pounds of	25	11	18	
Value of	$5.00	$0.44	$0.90	$6.30
Red clover:				
Pounds of	41	7.6	44	
Value of	$8.20	$0.30	$2.20	$10.70
Less value of nitrogen				8.20
Net exhaustive effect of clover when removed				$2.50

If clover takes from the air as much nitrogen as the crop removes, leaving the soil as well supplied as before, we may then subtract the cost of nitrogen, in estimating the exhaustive effect on the soil. If the clover is plowed under it adds materially to the nitrogen supply.

Time of Harvesting Grasses and Legumes.— As pointed out before, grasses continue to increase in total dry weight up to the time that the seeds reach the hard dough stage. In general, grasses increase about one-fourth in dry weight after blossoming, while clovers reach maximum weight about time of full bloom. After this legumes decline in total weight, probably due to the loss of leaves. This should be considered in determining the best time to harvest.

Summing up, we find that legumes have a quite different root system than grasses and at least some of them probably draw more heavily on the subsoil. They differ in composition, legumes being higher in protein. Legumes do not exhaust the soil nitrogen, though they draw more heavily on the potash supply. Legumes reach maximum growth at full bloom, while grasses increase one-fourth after this period.

HOW LEGUMES TAKE NITROGEN FROM AIR

During the Roman period it was known that legumes were beneficial to the soil. Jethro Tull, a prominent English agriculturist, made frequent references to the value of legumes as soil improvers in his writings, 1700–1725. Certain facts about clover

were well known to these early writers, as (1) clover needs a limestone soil; (2) that land may become "clover sick"; (3) and that it increased production of the soil.

Several theories were advanced as to why clover improved the soil. Some thought it to be deeper rooted. Liebig (1840–1850), a German chemist, thought all plants took nitrogen from the air through the leaves, and legumes, owing to the broader leaves, took up much more than grasses.

From this time on various scientists investigated the problem, but it was not until 1886 that Hellriegel, another German chemist, was able to explain the matter. Among his later experiments the following may be noted:

When he planted peas in pots filled with sterile soil, they would germinate, grow a short time, and die, though occasionally one would live and do well. He then took forty pots and filled them with sterilized soil, but ten of these he wet with leachings from a fertile soil. In these ten pots the peas did well, but twenty-eight out of the thirty remaining died. On the plants that lived he found root nodules. He concluded that the nodules were necessary for growth. As it had earlier been proved that these nodules contained bacteria, it was soon established that the bacteria caused the nodules, and that it was through the agency of these bacteria that nitrogen was taken from the air.

The bacteria are minute, rod-shaped bodies called *Bacillus radicicola*. They may live in the soil for many years. When the bacteria come in contact with a legume root, they enter the root hairs. This irritation causes the growth of a nodule, enclosing the bacteria, which multiply rapidly. The bacteria take up nitrogen from the air and supply it to the plant, while the plant furnishes other food matter for the bacteria. The plant and bacteria are, therefore, mutually helpful to each other, and this relation is called *symbiosis*.

Forms for Different Legumes.—While the same species of bacteria is apparently found on all legumes, yet there is some slight difference in the forms, as the bacteria for one kind of legume will not inoculate another variety of legume except in a few cases. Clover is not benefited by the bacteria from peas or alfalfa. However, alfalfa, sweet clover, and burr clover do have the same form, and

bacteria from one of these plants may inoculate the other. At present no other case is known of cross-inoculation.

How to Inoculate.—When the value of inoculation was first discovered (1887), the method recommended was to take soil from a field where the particular plant was known to grow well and spread it over the new field. The soil from the old field should be taken from the upper six inches and transferred, without permitting it to dry out, to the new field. From 200 to 300 pounds per acre is sufficient if carefully applied. As sunshine is a strong bactericide, it is best to apply on a cloudy day or toward evening and immediately harrow in.

Artificial cultures are made by growing the bacteria in a culture solution, and applying these pure cultures to the seed just before sowing or to the soil. The first artificial cultures were made about 1896, but for many years were unsatisfactory, and the soil method of inoculation was best up to recently. New methods of handling artificial cultures have been developed and they are now quite satisfactory. Full directions for using the cultures are usually furnished with each kind.

Natural inoculation is sometimes secured through bacteria which adhere to the seeds. This is more common with rough-coated seeds like sweet clover in the hull or burr clover. It has frequently been observed, in sowing alfalfa on a new field, that only an occasional plant would survive the first season. Examination usually shows those occasional plants to have nodules, probably from bacteria on the seed. If such a field is replowed, harrowed to scatter the bacteria and sown a second time, usually thorough inoculation is secured.

Need of Inoculation.—Some legumes have greater need of inoculation than others. When alfalfa or red clover is sown on fields where there are no bacteria, the plants usually live for three or four months, then begin to die. Soy beans and cow peas, while greatly benefited by bacteria, will do very well on good soils when there is no evidence of nodules on the roots. Field peas, vetch, white clover, and alsike clover are all grown with little difficulty on good soils, without inoculation. However, the bacteria are beneficial in most cases. If no bacteria are present the legume exhausts the nitrogen supply of the soil the same as other plants.

SOILS FOR LEGUMES

Certain legumes are well known as crops that can be grown on poor soils, as field beans and cow peas, the old adage "too poor to sprout black-eye peas" being the last word on poor soil. Other legumes require good soils, notably alfalfa, which seldom succeeds

FIG. 167.—Plot on right had lime applied, on left no lime. Note difference in amount and growth of red clover.

except on good, productive soils. The common legumes may be roughly grouped as follows:

1. Legumes that will grow on poor soils: Beans, field peas, cow peas, alsike clover, lespedeza, burr clover.

2. Legumes requiring better soils: Red clover, sweet clover, vetches, white clover, soy beans.

3. Legume that grows well only on good soils: Alfalfa.

Lime Requirements of Legumes.—Certain of our most important legumes require a good supply of lime in the soil, notably alfalfa and red clover. Many are indifferent to lime and others prefer an acid soil. The matter has never been clearly worked out, and available data are conflicting, but the common legumes may be roughly grouped:

1. High in lime requirements: Alfalfa, red clover, sweet clover.

2. Low in lime or slightly deficient in lime: Field beans, soy beans, vetches, peas, white clover, alsike clover.

3. Soil may be very deficient: Cow peas, lespedeza or Japan clover, burr clover.

4. Prefer acid soils: Florida beggar weed and velvet bean.

It is not intended to mean that the plants actually prefer the conditions indicated in each group, but will do fairly well in such condition. For example, alsike clover responds to lime and prefers a limestone soil (Fig. 167), but yet will grow fairly well on soil lacking in lime, where red clover will fail.

QUESTIONS

1. State the important facts about the legume family.
2. How is the pea family separated from the rest?
3. From what does it derive its name, legume?
4. Describe the clover family.
5. The alfalfa family.
6. How many important families of legumes are grown for forage?
7. Name as many as you can.
8. Compare legumes and grasses in depth and amount of root.
9. What per cent of root in the surface six or eight inches?
10. Compare the root system of timothy and red clover.
11. What proportion of the plant is root?
12. Compare legumes and grasses in chemical composition.
13. Compare legumes and grasses with grain crops as to effect on productivity of soil.
14. Compare legumes and grasses as to effect on soil exhaustion.
15. Compare legumes and grasses as to time of harvesting for maximum yield for best quality.
16. How long has the value of legumes been known?
17. Early theories as to why they were valuable.
18. When was the secret of their value discovered?
19. By what means do they acquire nitrogen from the air?
20. Do all legumes have the same bacteria?
21. Tell how to inoculate with soil. With artificial culture.
22. What is natural inoculation?
23. Is inoculation equally important for all legumes?
24. State the variation of legumes as to soil requirements; as to lime requirements.

CHAPTER XLI

ALFALFA

Alfalfa is at present the most important cultivated forage crop in the west half of the United States. As a leguminous crop, it has about the same relation to the western half of the United States that red clover does north of the Ohio River and the cow pea crop south of the Ohio River. While its culture is increasing in the eastern half of the United States, it is doubtful whether it will ever attain an extensive culture.

Origin and History.—Alfalfa is probably the oldest cultivated forage crop. Its culture seems to have originated in Persia and Asia Minor. Wild forms similar to the cultivated variety are found growing in this region. Here it was cultivated at least five hundred years B.C. and not long afterwards introduced into Greece during one of the early Persian invasions. It seems to have reached the Roman Empire about the beginning of the Christian era, and slowly spread from there northward through Europe, reaching England early in the seventeenth century. It was early introduced into North America and South America. It is mentioned occasionally in the early history of the colonies, and has been in continuous culture about Syracuse, New York, for at least a hundred years. Its agricultural history in the United States, however, really begins with its introduction into southern California from South America in 1854. The culture of alfalfa spread eastward, especially in the irrigated districts. The crop had a very rapid development in Kansas and Nebraska (Fig. 168) during the decade from 1890 to 1900. This was probably due to the fact that the native prairie hay had largely disappeared by that time, and no other cultivated forage plant was found to succeed so well as alfalfa. Since 1900, considerable effort has been made to spread its culture east of the Missouri River, but here it must come into competition with timothy and clover, which are easier to grow and better adapted to rotation. Also, the soils are not naturally well suited for alfalfa culture without special treatment and inoculation. Its development has therefore been slow, but in time will probably attain a more important place.

Climatic Requirements.—Alfalfa originated in a region with an extremely hot dry climate. It seems to flourish in a hot climate if it is also dry, but will not withstand a hot humid climate. The common cultivated forms are limited in their northern extension by winter killing. In general the northern limit of common alfalfa is through South Dakota to central New York. However, there is great variation in the winter resistance of different strains. This is well

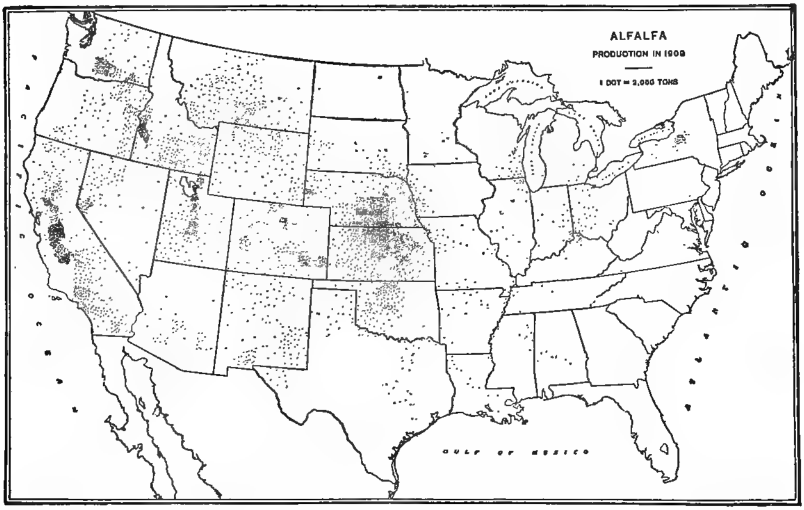

Fig. 168.—Distribution of alfalfa in United States. (From U. S. Census, 1910.)

illustrated by very extensive experiments conducted at Dickson, North Dakota, in the years 1908–1909. The following data are selected to illustrate the difference in hardiness:

Hardiness of Alfalfa

Source of seed	Per cent surviving
4 strains from Arabia	00.00
5 strains from South America	00.40
5 strains from Germany	16.90
3 strains from Nebraska	23.60
12 strains from Turkestan	27.70
3 strains from Montana	34.60
2 strains from Canada	54.60
3 strains from Mongolia	66.50
1 strain Grimm alfalfa (Minn.)	93.00
1 strain Grimm alfalfa (Dakota)	97.20

There are many varieties of alfalfa besides the common cultivated form, and some of these are semi-tropical in character and not hardy north of the southern part of Arizona or Texas. One species of alfalfa, known as Siberian or sickle alfalfa, is found growing wild as far north as 60° latitude in Siberia. The relative hardiness of the different types is better understood by considering the alfalfas when classified into natural groups.

Classification of Alfalfa.—The following grouping of the common cultivated varieties is arranged according to degree of hardiness:

Semitropical forms: Peruvian, Arabian.

Blue-flowered alfalfa: Common, Turkestan.

Variegated flowers: Sand Lucern, Grimm alfalfa, Ontario variegated, hardy Blackhill types.

Yellow flowers: Siberian or sickle.

The semitropical forms are characterized by very large size and rapid growth. As many as ten or twelve cuttings of these can be made in southern California. They also have a hairy covering, and many of their flowers are a plum-colored blue.

The blue-flowered alfalfas, so-called, are the common cultivated types. The flowers vary from blue to purple. The range northward of the common alfalfas has already been described as South Dakota and central New York. In appearance it is impossible to distinguish common alfalfa from Turkestan. However, records show that in a general way the Turkestan is somewhat less productive, having a tendency to be a little more dwarfish in habit, and usually does not recover so quickly after cutting. It is claimed to be a little more drought-resistant and cold-resistant, and it is probably true that at least some strains of Turkestan are. However, Turkestan seed is produced under a wide range of conditions in western Asia, and it is not safe to assume that any particular lot of commercial seed would be satisfactory. The culture of Turkestan should not be encouraged, now that we have known strains of hardy alfalfa in North America.

The variegated alfalfas are thought probably to have originated from hybrids between the yellow-flowered alfalfa and common blue-flowered alfalfa. A certain per cent of the flowers are quite variable in color, ranging from white through yellow, greenish, to light blue

or purple. Generally, however, the variegated flowers constitute only a small per cent, ranging ordinarily from about one to ten per cent. The rest of the flowers are indistinguishable from those of ordinary alfalfa. The oldest cultivated form of variegated alfalfa is known as Sand Lucern in Europe. It is highly probable that all the variegated or "hardy" alfalfas come from Sand Lucern, as it is known that the original seed of all of them was brought from central Germany, where Sand Lucern is cultivated. They are all similar in appearance, but undoubtedly acclimation has given some slight difference in hardiness and yield. These alfalfas are all much more winter-resistant than the common blue alfalfa, and are coming to be known on the market as "hardy" alfalfas.

Yellow-flowered or Siberian alfalfa is of little agricultural value. It is a native plant found growing throughout Siberia, and is said to be an important part of the native herbage. Yellow alfalfa is rather prostrate in habits of growth, and has underground rhizomes. It usually produces but one crop a year. We have most interest in this plant because of its great hardiness and the possibility of hybridizing it with other alfalfas to secure hardy strains. The variegated alfalfas, which are supposed to have originated from one of its hybrids, show some tendency to partake of the qualities of Siberian alfalfa, in having variegated flowers, a slight tendency to prostrate stems, and the occasional production of rhizomes.

Alfalfa Roots.—Alfalfa probably sends its roots deeper than any other cultivated plant. In ordinary soil, where grasses would root one to two feet deep, the cereals or red clover four to five feet deep, alfalfa usually penetrates eight to ten feet. On some of the soils in the western States, that are uniform and to a great depth, alfalfa roots often penetrate twenty to thirty feet.

The typical alfalfa plant in loose soil has a straight tap root which may be from one to two inches in diameter at the top. Small lateral roots are given off in large numbers. However, the root is greatly modified by the character of the soil. If this straight tap root finds a stratum of hard subsoil, it is usually broken up into a much-branched root. Alfalfa grown on hard, compact soil usually develops a series of large branch roots rather than tap roots.

Certain forms of alfalfa have a tendency to produce more

branched roots than others. It is said that the variegated alfalfas have a tendency to produce branched roots, and that this character is correlated with winter hardiness. However, the character of the soil so affects the type of root that no very accurate information has been collected as to the root structure of the different forms and its relation to hardiness.

Development of Shoots.—A strong alfalfa plant, under average conditions, will produce from twenty to fifty stems, although individual plants have been known to produce as high as three hundred. The top of the plant is known as the "crown," made up of a series of short, heavy branches. Buds arise from any point on these branches down to one or two inches below the surface of the soil. Usually as soon as the first set of stems have reached full height, a new crop of buds develops, ready to grow up at once if the old stems are cut away. Under ordinary conditions, a new crop of stems will be produced every forty days. The only condition that seems to retard the development of new buds is extreme drought. In very dry regions the first crop of stems may even blossom and mature seed, the whole time taking eighty or a hundred days, with very little tendency to develop new buds, unless rain comes or irrigation water is turned on.

In humid regions it is usually believed best to cut the hay when the new buds are well started, or about two to three inches in length.

Life Period of Alfalfa.—In humid regions, from six to ten years is considered the average life of an alfalfa meadow. It is much longer lived in dry regions, and has been known to live at least fifty years and produce good crops in semi-arid countries. In the northern States the plants are very commonly killed through winter injury. On heavy clay soils the plants are heaved out by hard freezing. In other cases they seem to be killed by hard freezing. In humid regions the old plants are usually sooner or later attacked by some form of rot, and after a year or two succumb.

Submerging is very injurious to alfalfa. A strong alfalfa field will often be killed out by flooding not more than two or three days. This is especially injurious on flat lands during the early spring thaws. A thin layer of frozen water for only one or two days will

usually destroy the plants. In arid regions, where the plants are free from winter killing and the ordinary fungous diseases that cause root rot, alfalfa plants are very long lived.

Pollination.—It has long been known that alfalfa produces flowers more freely in dry, sunshiny climates than in humid regions. In northeastern United States very few flowers are produced, especially on the first crop, when the weather is likely to be humid. It is very seldom that a seed crop is produced in this section. In the drier regions there is usually no difficulty in securing a seed crop, and this seems to be due to the fact that plants flower much more abundantly, and natural facilities to secure pollination are better.

In alfalfa the stigma and anthers are tightly held in the lower part of the flower. Unless they are freed by "tripping," fertilization will not take place. This can be demonstrated by taking mature alfalfa flowers and touching the inside of the flower with a fine-pointed pencil or toothpick. Under field conditions, it is probable that insects do most of the tripping. It has also been observed that the flowers will trip naturally in dry weather under bright sunshine.

Soils for Alfalfa.—While it is generally supposed that alfalfas prefer a loose, pervious soil, due to the deep root system, it is nevertheless found growing very successfully on some of the heaviest gumbo clays. If fertility and moisture are available, the texture of soil does not seem to be important.

Drainage is very important, as alfalfa will not live on wet land or land where the water table comes to the surface at any time during the year. The water table must be kept at least two feet, and better three to four feet, below the surface.

Alfalfa also requires a very fertile soil. While most of the clovers can be started in poor soil and are recommended as a crop to build up poor soils, this is not true of alfalfa. In general, land that would not produce twenty-five bushels of wheat or forty bushels of shelled corn in a fair season is not suitable for growing alfalfa until it has been manured or fertilized.

Lime.—Sufficient lime in the soil is also very important. The lack of lime is one of the principal reasons why alfalfa culture has

been limited to the States east of the Mississippi River. Outside of the limestone soils, it is necessary to have considerable lime to insure alfalfa.

Manure and fertilizers are practically necessary on impoverished soils. Alfalfa responds to barnyard manure better than any other of the common forage crops. It has often been found that treating land with manure before seeding will secure a crop when all other means fail. Very little experimental work has been carried out in the application of fertilizers, but wherever tried alfalfa has usually responded well to the use of acid phosphate. Two hundred pounds per acre is recommended as a yearly application.

Methods of Seeding Alfalfa.—Alfalfa is generally sown without a nurse crop. This is largely because it is grown in a rather dry climate, where the use of nurse crops is not practical. In northeastern United States, alfalfa is commonly sown with a nurse crop, either winter wheat or oats, on the limestone soils. Outside of the limestone region, however, there is generally difficulty in securing a stand, and here it is usually sown alone.

Amount of Seed.—The amount of seed recommended per acre varies from ten to thirty pounds. Good stands have been secured with five pounds per acre, but the young plant is rather delicate and easily destroyed by weeds. Experience has shown that under average conditions about twenty pounds of seed per acre should be used. In the drier regions, where farmers prefer thin sowings of all crops, ten to twelve pounds is commonly recommended. Some growers prefer to sow as high as thirty pounds, as they believe the thick stand gives them a finer quality of hay and also that the meadow will last longer.

Inoculation for Alfalfa.—As pointed out in a previous chapter, inoculation is necessary for most legumes. Alfalfa culture was hindered for many years before we knew about the necessity of inoculation. Alfalfa seed often carries a little natural inoculation, and it was early observed by farmers that if a field were sown to alfalfa and failed to grow more than a few plants, if it was plowed under at once, thoroughly worked up and resown, a stand would usually be secured the second time. This became a recognized rule

among growers before they knew the explanation. The natural inoculation, however, on the few plants that succeeded, was enough to inoculate all the soil when it was replowed and scattered through.

The most successful method of inoculation up to recent years has been to carry soil from an old alfalfa field to the new one. Two hundred to three hundred pounds of soil per acre is usually sufficient. When the soil is transferred, care should be taken not to allow it to become too dry, and as soon as it is spread on the land the ground should be cultivated or harrowed, as exposure to bright sun is injurious. An excellent way is to mix the soil with manure and apply it with a manure spreader. The manure furnishes a good medium for the bacteria, and often insures inoculation when it is difficult to secure it otherwise.

At present artificial culture may be purchased or secured from the agricultural colleges and the United States Department of Agriculture, which is very simple to apply and generally successful if directions are carefully observed. In a limestone region, after alfalfa has been cultivated for a number of years, it is generally no longer necessary to inoculate when sowing, as natural inoculation spreads and seems to remain in the soil for many years. On soils that are not naturally rich in lime it is advisable to inoculate whenever alfalfa is sown.

Time of Sowing.—Alfalfa may be sown any time during the spring or early summer. The principal objection to this is that, no crop being harvested that season, the use of the land is practically lost. Also, if the land is infested with weeds, it is not possible to free the land from weeds before sowing alfalfa. For these reasons many farmers prefer to sow in late summer or possibly in early fall, after a grain crop has been harvested. In the northern limits of alfalfa culture, it should not be sown later than the first of August, but southward, the season may be correspondingly later (Fig. 169).

One of the main precautions in fall seeding is to have a very firm, compact seed bed, as alfalfa will go through the first winter much better on a solid seed bed than a loose one. For this reason many farmers do not plow for fall seeding, but merely work up the land thoroughly with the disk and cultivator.

Harvesting Alfalfa.—For the largest total yields it is necessary to cut alfalfa promptly whenever it is ready. Many western farmers plan to cut the alfalfa when it is about one-fourth in bloom. This rule, however, will not do in the northeastern States, where alfalfa very often fails to bloom. It is much better to watch the development of new buds from the crown of the plant. As soon as these are

FIG. 169.—Alfalfa plants from seedings sown in August, September and October, and taken up following April. Illustrates importance of early fall sowing to secure good, strong plants. (Nebraska Experiment Station.)

well started, the hay should be cut promptly. Usually the cutting of hay can be made every thirty or forty days during the growing season. This will give about three cuttings in South Dakota, and five or six cuttings in Texas.

The yield of alfalfa depends very largely upon the fertility of the land and water supply. The average yield for the United States

is about two and one-half tons per acre, but on many farms an average of three and one-half tons is made. Large yields of five to six tons are not uncommon.

The Seed Crop.—The commercial seed crop of alfalfa is grown principally in Utah, Kansas, Nebraska, California, and Arizona. It is grown only in bright, sunshiny climates, and usually with a low water supply. A large proportion of the seed is grown in the irrigated districts, but water is usually withheld from the seed crop. East of the Mississippi River alfalfa will usually not produce a profitable seed crop oftener than once in three or four years.

The most favorable weather for securing a good seed crop is generally the hottest and driest portion of the summer. In the northern States it is the general custom to leave the second crop for seed, while from Kansas southward the third crop is left more often. An ordinary yield of seed varies from three to six bushels per acre, while eight to ten bushels is considered a very large yield.

Growing Alfalfa in Rows.—On the high, dry plains much alfalfa is grown in cultivated rows. The rows are usually from two to three feet apart. This method is considered practical only in regions where the average rainfall is below fourteen or sixteen inches. Very good seed crops can be secured in this way, and the method is practised principally for seed growing on dry soil without irrigation.

Cultivation of Alfalfa.—In most regions where alfalfa is grown, as the stand begins to thin out, native grasses, and especially blue-grass, begin to come in. To keep out these grasses, many growers practise disking or harrowing their fields early in the spring and after the first cutting. If the work is done with care and judgment, it is possible to keep down the incoming grasses to a large extent.

It has also been thought for many years that the yield could be increased by disking alfalfa sod, the theory being that the disk would split up the old crown, causing a thicker stand. Experiments with disking have usually shown an increased yield the first year or so

that it was practised, after which the yield usually declined. The indications are that the disking does stimulate and increase growth, but it also injures the roots and permits various fungous diseases to enter and cause root rot, so that in a year or two the plants die out very rapidly. In dry climates, however, root rots are not so very troublesome, and the disking may be expected to give good results longer in such climates than where it is humid. In humid regions it is agreed that disking is justified only on old fields that are to be plowed up the following year.

Alfalfa cultivators of various forms have been put on the market.

FIG. 170.—Alfalfa seed and dodder seed.

Some of these are constructed like disk harrows, with spikes in place of the disks. Others are constructed like cultivators, with very narrow teeth on flexible beams. The latter form is now generally considered to be the best.

Pasturing Alfalfa.—Alfalfa is considered to furnish the best hog pasture of any cultivated forage crop. It is not considered well suited for cattle or sheep, as they are practically sure to bloat. No method of overcoming this difficulty has been found, where pure

alfalfa is used. However, where the pasture is about half alfalfa and half grass, little difficulty is experienced.

The principal precaution in pasturing alfalfa is not to graze it too closely. It is generally thought best to have enough stock on to keep it only partly eaten down, and make at least two light cuttings of hay during the season. Close grazing for one season will usually destroy alfalfa, while it may be grazed for a number of years, with proper care.

Conditions seem to be somewhat different in dry regions. In very dry climates it can be pastured without much danger from bloat and is usually not easily destroyed even by rather close grazing. The reasons for this are not very apparent, but usually in dry soil the crowns of the plant are very much deeper set into the ground.

FIG. 171.—Alfalfa dodder.

Diseases and Enemies.—While there are a number of diseases found on the alfalfa plant, only one or two are important.

Dodder, or love vine, is a parasitic weed found on both alfalfa and clover (Figs. 170 and 171). Dodder is a leafless vine which attaches itself to the plant and lives by absorbing nourishment. It is propagated by small seeds. The seeds germinate in the spring, but as soon as the young plant has attached itself to alfalfa, the roots die. It usually spreads rather rapidly. If only a few small areas are found in a field, these can be destroyed by cutting the alfalfa plants very low and burning all the material.

Where the field is generally infected, it will probably be necessary to plow up the field, in which case it should not be put back to alfalfa for at least two or three years.

Alfalfa leaf spot occasionally gives trouble. Small, dark brown spots appear on the leaves and cause them to drop off. When this disease is abundant, the plant makes a very poor growth. The crop should be cut at once, after which it usually will be free from the disease the rest of that season.

Root rot is generally used to describe any ordinary decay of the root, although there is a specific disease of this character. The most common root rots are comparable to the rotting of any woody plant which has been injured, allowing ordinary fungous diseases to enter and cause slow decay.

Insects.—*Grasshoppers* are sometimes injurious, especially to new seeding. This is more likely to be true when alfalfa is sown in the fall, and grasshoppers are likely to migrate in large numbers, as their own natural food supply decreases.

The alfalfa leaf weevil made its first appearance in this country about 1904. The insect is most injurious to the first crop, when the larvæ may appear in large numbers and almost destroy it. The crop should be cut as soon as the larvæ appear in large numbers. Then the field should be thoroughly gone over with harrows and brush drags to destroy what insects may be on the ground. This treatment not only kills directly many of the larvæ, but also strips the stubble of leaves, helping to starve them.

QUESTIONS

1. Where has alfalfa attained greatest importance?
2. Describe its early history and introduction into the United States.
3. Describe the climatic requirements of alfalfa.
4. Does it vary in cold resistance?
5. Classify the principal types of alfalfa.
6. Compare common alfalfa with Turkestan, with variegated alfalfa, with yellow alfalfa.
7. Describe alfalfa roots on various soil types.
8. Compare the root systems of common, variegated, and yellow alfalfa.
9. Describe the development of new shoots.
10. How long does alfalfa live under various conditions?
11. Give the effect of submerging. Other causes of death.
12. What are the conditions effecting pollination?
13. Give soil requirements of alfalfa. Lime requirements.
14. Fertilizers for alfalfa?

15. How is alfalfa usually sown?
16. What amount of seed is used per acre?
17. Give the best method of inoculation.
18. What are the best times for sowing alfalfa?
19. What precautions are observed in fall sowing?
20. State time to harvest alfalfa.
21. Where is the seed crop grown?
22. What climatic conditions are required?
23. Describe the culture of alfalfa in rows.
24. Give principal reasons for and against the cultivation of alfalfa fields.
25. Name precautions to be observed in pasturing.
26. Describe the principal diseases and insect enemies of alfalfa.

CHAPTER XLII

THE CLOVERS

RED CLOVER

Red clover is now the most important forage crop in North America (Fig. 172). Its easy culture, high feeding value, adaptation to growing with timothy, and adaptation to systems of crop rotation are the reasons for its popularity.

Origin and History.—Red clover is found growing wild throughout temperate Europe, western Asia, and north Africa. In its wild form, it is quite variable, and many varieties have been described. Little is known about its early culture, but it had a recognized agricultural value as early as the thirteenth century, was rather common throughout Europe in the seventeenth century, and very extensively cultivated in the eighteenth century. It was undoubtedly among the first plants introduced into North America, and is distinctly mentioned in 1747.

Red clover is cultivated at present as far south as Tennessee, but the area of its most extensive culture is from the Ohio River northward, including the provinces of Ontario and Quebec in Canada. Its culture extends westward to the great dry plains region, which in general would be fifty or one hundred miles west of the Missouri River. It is also cultivated in the northwestern States. Red clover is very cold-resistant, and is seldom killed out by freezing, but it is limited southward and westward by the hot, dry weather in midsummer.

In the South red clover is regarded as a winter annual. It can be sown in the fall and will make a light crop the following season, but is usually killed out the following August.

Soils for Red Clover.—Red clover differs from alfalfa in preferring humid regions and very moist soil. It, however, is like alfalfa in having a very high lime requirement. It has been noted that red clover culture is declining throughout the eastern States during the past decade. This is apparently due to the decreasing

FIG. 172.—Red clover, upper figure, and white clover, lower figure.

lime content of the older cultivated soils. Most of the eastern soils contain sufficient lime for red clover when first brought under culti-

vation. The lime content has steadily declined and with the decline red clover culture has become increasingly difficult. Many large regions that grew red clover twenty-five or thirty years ago can no longer produce it without the use of lime.

Agricultural Varieties.—While there are several regional strains of red clover which differ in small detail, there are only two recognized varieties with a marked difference. They are usually

Fig. 173.—Sowing red clover in fall wheat with special grass-seed drill.

known in the market as medium red clover and mammoth clover. The principal differences are: (1) Mammoth clover is about two weeks later in blossoming. (2) The stems of medium red clover are usually hollow, and those of mammoth clover are solid. (3) Medium red clover will usually make both a hay crop and seed crop the same season, while mammoth clover will make only one crop.

A form differing somewhat from common medium red clover, introduced from Russia, and known as Orel, has been tried with considerable success in the United States. The United States Depart-

ment of Agriculture conducted a rather extensive experiment, with different strains of clover, from different sources, in 1905. The data, however, were so variable that no conclusion could be drawn as to the relative merit of seed from different regions.

Sowing Clover.—Red clover seed may be scattered upon the land almost any winter month, from October to April, with reasonable expectation of success. It is, however, very largely sown in March and April. It is considered best to sow it during the spring when alternate freezing and thawing of the soil is taking place. It is usually sown on winter wheat, or with spring grain (Fig. 173).

Fig. 174.—Seeds of the clovers. Upper row: Red clover; crimson clover; trefoil; Japan clover. Lower row: White clover; alsike clover; sweet clover; alfalfa.

Midsummer is the most unfavorable time to sow red clover, as the young plants do poorly during hot, dry weather.

In the southern States red clover is commonly fall sown. This is good practice as far north as it can be depended on to withstand the winter. Probably fall sowing is not practical very much north of central Ohio as a regular practice. In central Ohio it should be sown by the first week of August to insure it going through the winter. Compare the seed of red clover with others (Figs. 174 and 175).

Rate of Sowing.—About eight pounds per acre is the standard rate of sowing when mixed with timothy, or ten to twelve pounds when sown alone. About four-fifths of the red clover is sown as a mixture with timothy. On lands where red clover is apt to fail more or less, due to lack of lime, it is a common practice to mix red clover with alsike at the rate of five pounds to three. Alsike clover will grow on portions of the field deficient in lime. The use of red clover in mixtures has been fully discussed in another place (see page 317).

Fertilizers for Clover.—In fertilizing clover, it is usually not necessary to provide nitrogen, as the plant is capable of gathering its own nitrogen supply. Clover plants seem to respond especially to

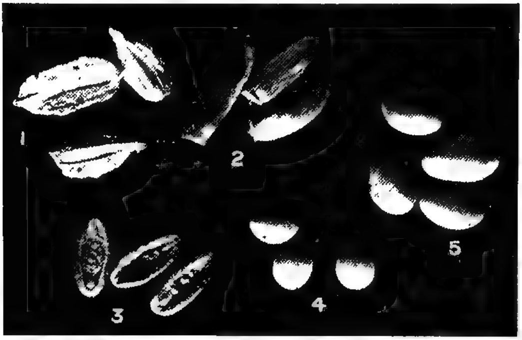

FIG. 175.—Red clover seed and common weeds often found in it. (1) Wild carrot, (2) daisy, (3) buckhorn, (4) dodder, (5) red clover.

potash, and on many soils phosphate also is required. In fertilizer trials it has generally been noted that where large amounts of nitrogen were applied, the grasses would tend to run out the clover; on the other hand, where potash was applied in relatively large quantities, the clover tends to run out grass. As clover is usually sown with small grain, the fertilizer is applied to the grain crop, and seldom directly to the clover crop.

Clover in Rotation.—The principles of crop rotation and the use of clover have been fully discussed in a previous chapter. Red clover fits better than other legumes into the kind of rotation suitable for grain farming. It can be sown with a grain crop, so that the land is not out of use while the clover is becoming established. It

makes a very vigorous growth the following season, and the land can be plowed the next year to be put back to grain. It has been demonstrated that clover, once in four years, will ordinarily maintain the nitrogen and organic supply of the soil, under grain farming.

Roots of Clover.—Red clover has a branching tap root. The main roots usually penetrate to a depth of four or five feet. While about 75 per cent of the clover roots are in the upper eight inches, they are not so concentrated in the upper soil strata as grass roots. Red clover is thought to draw considerable more of its moisture and plant food from the lower soil strata than grass.

The amount of root residue in the soil has been determined a number of times. The data usually vary from 1000 to 5000 pounds per acre of dry weight. Most of the figures, however, will average not far from 1000 pounds. The proportion of roots to stems has frequently been estimated, with great variation in result, but in general there is about one pound of root to two pounds above ground.

Stems and Leaves.—Red clover has a rather high proportion of coarse stems. A mature plant usually has about 60 per cent stem, 30 per cent leaves, and 10 per cent flower heads. The relative value of these different parts varies. The average protein content of the different parts has been determined to be about as follows:

Stems	8.6 per cent
Leaf stalks	11.2 per cent
Flower heads	18.2 per cent
Leaves	24.6 per cent

It may be also stated that the large stems contain a great deal of woody matter and are not highly digestible.

Harvesting Red Clover.—In general, clovers reach their maximum yield when in full bloom, after which they usually decline, probably due to loss of leaves. There is also a decline in quality as the stems become more woody. In this respect clover differs from grass, since grass usually increases in weight at least one-fourth after the blooming period. The only serious drawback to the mixing of red clover with timothy is the fact that red clover matures about two weeks ahead of the timothy and has usually declined in quality by the time the timothy is ready to cut.

Red clover grown alone is not easy to cure into a good grade of hay. It is apt to turn very dark in color, and, if the weather is unfavorable, is apt to make very dusty hay. One important matter to keep in mind is to preserve as far as possible the leaves and small stems, as they are, pound for pound, worth about twice as much in feeding value as large stems.

Brown Hay.—As clover hay is so difficult to cure when the weather is wet, it is sometimes made into brown hay. By this method the hay is put into stacks or barns when wilted. It soon develops a high natural heat that prevents decay and soon dries it out. The hay is a dark brown color, with a decided odor. There is some loss in valuable feed material by this method, but it is considered quite satisfactory. The principal disadvantage is the large amount of labor involved in handling green hay.

Ensilage.—Red clover is sometimes put in the silo, but, like most legumes, does not make a first grade of silage if used alone. The silage is likely to be somewhat soft and acid. It is usually better to mix it with some grass crop for silage purposes.

Pollination and Seed Production.—It is well known that red clover requires the agency of insects before it will produce seed. This is due to the fact that pollination will seldom take place by natural means. Experiments have frequently been tried by covering clover plants with screens to keep out the insects. Under such conditions, it is rarely that seed will be set. However, if bumblebees are introduced under the screen, seed is readily developed. While several insects produce pollination in clover, the bumblebee is recognized as most important. Cross-pollination seems to be necessary in clover, and bumblebees seem better adapted than other insects for carrying the pollen from one plant to the other.

The Seed Crop.—The second crop is generally used for seed. It is found that the second crop usually produces a larger yield of seed, though the reason for this is not well known. Some think that the hot summer weather favors seed production, and also that there are more bumblebees at that time of year. The most important reason, however, for using the second crop for seed is that practically two crops are obtained this way in a season, while if the first crop is allowed to go to seed, the plant usually dies, and there is

no aftermath. In the northern part of the clover belt the season is not long enough to harvest both crops. When seed is grown here, it is the usual custom to pasture the clover till about June, or to clip it off at that time with the mowing machine. This is thought to give not only a more uniform crop, but to give a better seed crop by bringing the seed production later in the season.

One reason why mammoth clover is not more generally grown is due to the higher price of seed, the seed being higher because it will produce only one crop a year. Most of the red clover seed is grown in regions where the second crop can be harvested.

Harvesting Seed Crop.—The seed crop is generally cut with a mowing machine. Sometimes a buncher attachment is used, which leaves the clover either in wind-rows or bunches. It may be cured in the field and then put in stacks, or it is sometimes left in the field for several weeks until the straw has more or less rotted. The threshing is usually done with a special machine called a clover huller.

Average yields are usually about two bushels per acre, but large yields of five or six bushels are not uncommon. It is very difficult to estimate the probable yield of seed. One method of estimating it is to collect a number of representative heads and shell out the seed. If there is a thick, full stand of clover, an average of ten seeds per head may be estimated as equivalent to a bushel per acre. As there is seldom a full stand of heads, it is probable that under average conditions the head should average nearer twenty seeds per head to equal a bushel per acre (Fig. 175).

Color of Seed.—Clover seed varies from a bright yellow to a dark purple in color. As a general thing, the seed from a single plant is more or less alike in color, and there is a general tendency for seed to produce plants yielding seed of the same color, though there is always great variation. Seeds also get darker or more purple in color as they ripen. In general, if the seeds are all mature, there appears to be no difference in the value of yellow or purple seed.

Diseases.—Many diseases are found in the clover plant, but none of them do serious injury. Clover anthracnose has been reported as serious in Tennessee.

Clover sickness is a term usually applied to the soil when clover can no longer be grown on land where it previously grew. The causes of clover sickness are not well known, but it has been demonstrated that one cause is the decreasing lime content of the soil. On many such soils the addition of lime has restored clover growing. It is claimed, however, to fail even where lime is added.

Inoculation for Clover.—In general, artificial inoculation has not been practised. It is probable that more or less natural inoculation is carried about on clover seed and probably in this way it was first distributed throughout the country. Red clover is so extensively grown that it has usually not been necessary to inoculate. However, in new regions, it is sometimes difficult to secure stands of red clover for many years, and it is probable this is due to lack of inoculation. Recent experiments have shown that in regions where red clover has not been cultivated for many years inoculation usually gives better results.

ALSIKE CLOVER

Alsike clover (Fig. 176) derives its name from the province of the same name in Sweden, where it has long been extensively grown. It seems to have been brought into cultivation probably in Sweden or that vicinity. It is mentioned as a cultivated forage crop in 1750. From there it spread to England and adjoining countries in Europe, and was apparently introduced quite early into the United States, though it does not seem to have been cultivated to any extent, at least, until 1850. The early botanist Linnæus thought it to be a hybrid between red clover and white clover, but it is doubtful whether this is the case.

Characters.—Alsike clover is a long-lived perennial, and in this differs from red clover, which is a short-lived perennial. The stems are about as tall as those of red clover, but are more slender and prostrate at the base. It also differs from red clover in having a more or less continuous growing season throughout the summer.

Climate and Soil Adaptations.—Alsike clover has a much wider range of adaptation than red clover. It naturally prefers a cool climate and wet soil; but it will endure at least as much dry

weather as red clover, and is more resistant to both cold and heat. This enables alsike to grow in several places where red clover fails, such as very wet soil, or in regions where red clover winter kills, and will also grow farther south where the summers are hot.

Fig. 176.—Alsike clover.

The quality of greatest importance from an agricultural standpoint is its ability to grow on land low in lime, where ordinary red clover fails. Where red clover does well, alsike can not compete with it, but red clover now fails more or less over such a large area, due to

the lack of lime, that alsike is coming to have an important place. Alsike also grows on the so-called "clover sick" soils, whatever the cause may be. At present alsike is grown mostly in the northern tier of States and province of Ontario in Canada.

Culture.—The culture of alsike clover is almost identical with that of red clover. The seed, however, is much smaller and five to eight pounds is considered a full seeding. On wet land alsike is very commonly sown alone or with red top. As red clover seems to make a natural mixture with timothy, both growing better in limestone soils, alsike seems to make a natural mixture with redtop, as both will grow on very wet soils and in soils deficient in lime.

Alsike is coming to be very generally sown in mixtures of timothy and red clover. In many regions where red clover is extensively grown, it is becoming somewhat uncertain, and in almost every field there will be certain areas where the red clover will be a partial or complete failure. It is now becoming very general to sow a mixture of five pounds of red clover to three pounds of alsike per acre with the timothy. The alsike will grow on all the spots where the red clover will be thin or fail, and thus insure a full stand of clover.

Alsike is also used in pasture mixtures, due to its adaptation to rather adverse soil conditions, and the fact that it is a very long-lived plant and will endure for several years. As a hay crop, alsike will yield about two-thirds as much as red clover on soils where red clover is at its best, but in many localities it will yield as much as red clover. Alsike usually produces a good seed crop, the yield varying from two to six bushels per acre. The seed has good vitality and grows very quickly.

WHITE CLOVER

White clover (Figs. 172 and 177) is found growing wild throughout temperate Europe and Asia. Since its introduction into the United States, it has spread very rapidly, and is found growing wild throughout almost all the cultivated area of the United States and Canada. It seems first to have been brought into cultivation in Holland and is sometimes known as Dutch clover. From this region it spread to the adjoining countries and England about 1750. It

seems to have been brought to the United States with the early colonists, for by 1747 it was already recognized as a wild plant in the eastern States.

Description.—White clover resembles alsike in being a long-lived perennial, but differs from both red clover and alsike in its ability to spread by means of creeping stems. This enables it to maintain itself under pasture conditions. A single plant will usually spread gradually in the same way that blue-grass does, till it occupies considerable area. Other clovers have no means of spreading from the roots, and usually, when the original plant dies, the clover disappears. White clover also has the ability to produce seed under pasture. The seed heads will rise not more than an inch or two above the surface, and then turn downward so close to the ground that they are not eaten off in the grazing. A considerable per cent of the seed is hard, and remains in the ground for one or more years before germinating. It sometimes occurs that white clover will almost disappear from a pasture during a series of dry, unfavorable years; but will usually return quickly with more favorable seasons. The fact that a certain amount of the seed is hard and remains dormant probably assists it to return.

FIG. 177.—White clover.

Adaptations.—White clover probably has even a wider soil and climatic adaptation than alsike. This would be especially true toward the warmer and drier regions. While both red clover and alsike will summer-kill in the cotton belt, white clover will survive, and is therefore of considerable importance as a pasture plant in the

southern States. Like alsike, it will also grow on land deficient in lime, but probably is not adapted to extremely wet soil on which alsike would grow.

Mixtures.—White clover is recognized as a natural mixture with blue-grass in the same way that alsike mixes well with redtop and red clover with timothy. Both white clover and blue-grass are permanent, long-lived perennials low growing in habit, spreading by creeping root stalks, and well adapted to both lawn and pasture purposes. They are commonly sown together for lawns, and almost always sown in permanent pastures. In pasture or lawn mixtures, usually about two to five pounds of white clover seed are used, or when sown alone, five to eight pounds of seed per acre. Like other clovers, it can be sown during any winter month or early spring. If sown in the fall, it should have at least two to three months before freezing weather comes in the northern States. White clover seed is grown mostly in Michigan and Wisconsin, in the United States, in Ontario, and several places in Europe. The seed is usually of good quality, and retains vitality two to three years.

SWEET CLOVER

Description. —There are three common varieties of sweet clover, generally known as white sweet clover (Fig. 178), yellow sweet clover and annual or "sour" clover. The white sweet clover is the largest and most vigorous type, and about the only one recommended for cultivation. It will grow from six to eight feet tall in ordinary good soil. Yellow sweet clover is not quite as tall, less branching and has fewer leaves. It probably would not yield more than half as much forage as the white variety. The annual sweet clover is a small variety growing from one to two feet in height, and an annual, while the two others are both biennial. The annual sweet clover, however, spreads very rapidly by natural means, and in some places furnishes considerable natural forage, being most prevalent at present in southern California.

Large white sweet clover, which is also known as Bokhara, meliot, or melilotus, and bee clover, is a native of temperate Europe and Asia. Since its introduction into the Western Hemisphere, it has

spread by natural means over much of both North and South America, where it is recognized as a common roadside weed. It seems to have been first cultivated probably in western Asia, and

FIG. 178.—Sweet clover.

was early brought to the American colonies, being distinctly mentioned as common in Virginia as early as 1739.

Sweet clover is a strong growing biennial, making a rather slow growth the first season, reaching a height of three to four feet. It will sometimes bloom at the end of the first season, especially in the

southern States. The second year it starts growth very early and grows with great vigor, reaching full height in about two months, or the first part of July in the northern States. If cut down for hay at this time, it will at once produce a second crop. In the southern States it may be cut three times during the season, but care should be taken not to cut the stubble too close, as the new stalks sprout from above ground.

Seed and Seeding.—The seed is produced very abundantly. It is usually the custom to cut the first crop for hay or pasture it down till about July first and take the second crop for seed. The seed shatters off very easily as it ripens, and it is generally necessary to cut the seed crop and handle it during damp weather or while the dew is on in the morning.

In nature the seed usually falls upon the ground in the seed pod, and remains till the following spring before germinating. Usually a high per cent of the seeds are classed as hard seeds; from forty to sixty per cent generally remain dormant during the first year. This quality makes sweet clover quite permanent under natural conditions, as there is usually some seed in the soil to germinate, even when one or two crops are completely destroyed. In the United States the seed is usually not free from the pod, but much of the European seed is recleaned and free from pod. In appearance the seed very much resembles alfalfa and is sometimes used to adulterate alfalfa.

In sowing sweet clover, it is most commonly sown either in the fall or early spring with wheat or rye. Much of the commercial seed on the market is of poor quality, probably due to the irregular demand and the seed stock becoming old and worthless. In some cases, however, the per cent of hard seed is so large that a poor stand will be secured the first year. For these reasons it is usually best to make a germination test of sweet clover seed before sowing.

Adaptation.—While sweet clover is very cold-resistant, seldom winter-killing even where red clover will succumb, it is also well adapted to southern climates. In fact, it is cultivated most extensively at present in Alabama, Mississippi and Kentucky. Sweet clover naturally prefers a soil well supplied with lime, being about in the same class in this respect as red clover or alfalfa. It is

such a vigorous plant, however, that the roots will often reach into the subsoil, where the lime supply is frequently sufficient when the surface is exhausted. For this reason we sometimes find it growing on soils where red clover and alfalfa would fail. Sweet clover is very commonly found growing wild along railroad cuts where the subsoil is exposed, which illustrates its ability to grow in raw soils, poor in organic matter, where most cultivated plants would fail. Sweet clover will also grow in impoverished sand hills, and sandy soils where few other cultivated plants would succeed, and for this reason is recommended as a plant for green manure on such soils.

Utilizing the Crop.—Sweet clover has a decidedly sweet odor, from which it derives its name. This odor is due to the presence of cumarin, which gives a peculiar bitter taste. Animals usually refuse sweet clover plants until they have acquired a taste for them. However, animals will usually eat the young plants readily, as these contain much less cumarin. If continued on sweet clover pasture, they acquire a taste for it, and there is no difficulty in using it as a pasture plant. When made into hay, a considerable proportion of the cumarin is volatilized, but the hay has a decidedly sweet odor and animals must be accustomed to it.

Sweet clover makes an excellent temporary hog pasture, and in some places is used to a limited extent for cattle pasture. It is claimed that if a part of the plants are permitted to go to seed in the fall of each year and the new plants allowed to make some start a continuous pasture may be maintained for several years, although the plant is really a biennial.

For hay, sweet clover should be cut just as it comes into bloom, as the large stems become woody very rapidly. Under favorable conditions a light cutting of hay can be made the first year it is sown, and two to three cuttings the second year. The second year it should yield three to four tons of cured hay per acre.

Inoculation.—Sweet clover grows naturally over such a wide area that many do not think it needs inoculation. It is probable that more natural inoculation is carried on the seed of sweet clover than most legumes, especially when it is sold in the rough. Experiments have shown, however, that it responds almost as well to inoculation

as alfalfa, and this is quite necessary in regions where it has never been grown. It happens, however, that it may be inoculated with the same bacteria as alfalfa, or by the use of soil from old alfalfa fields.

CRIMSON CLOVER

Crimson clover is a native of the warmer portion of Europe, occurring under favorable conditions as far north as England. It is cultivated in this region at present, and was probably introduced into the United States about a hundred years ago. It is only within the last thirty years, however, that it has come to be recognized as having much agricultural value in the United States.

Description.—Crimson clover, as its name indicates, has a conspicuous crimson or scarlet flower head. It is, strictly speaking, an annual plant, but in agricultural practice is generally used as a winter annual, being sown in the fall, and harvested early the next season.

Adaptation.—Crimson clover is not very cold-resistant, and in the eastern part of the United States is very seldom sown north of New Jersey. However, on the Pacific Coast it will grow as far north as Oregon and Washington. While crimson clover prefers limestone soils, it will grow on soils quite low in lime content, and seems to be one of the best plants to grow on sandy soils.

Crimson clover also does well in the Gulf States if sown early enough to make a good growth before winter, but the dry weather in late summer often makes seeding difficult. The region where crimson clover is at present of greatest importance is New Jersey and Maryland southward to the Carolinas. Here it has come to be a very important green manuring crop, as it can be sown in the fall, after a cultivated crop such as potatoes, or in the corn field, will make a good winter growth, and can be turned under by May of the following year for green manure.

Seed and Seeding.—Crimson clover seed is large, usually about twice or three times the size of red clover. It grows very easily, and twelve to twenty pounds per acre is the usual rate of seeding. The seed is largely imported from Europe at present, though it produces a good seed crop in America, but the business of harvesting the seed

crop has not been developed. It is the general custom in New Jersey to sow the seed in the fall, usually during August or September. North of New Jersey, when grown at all, it must be sown in the spring.

In the large potato and truck crop districts along the Atlantic Coast crimson clover is very generally sown after the potato crop is taken off. Probably the most common way of sowing it, however, is in the standing corn at the last cultivation. As it is grown more commonly for a green manure crop than hay, it may be turned under early enough the following season to put in another cultivated crop. It makes a very rapid growth during the fall and early spring.

Utilizing the Crop.—When crimson clover is cut for hay, it should be cut rather green, as the flower heads are covered with hard, stiff hairs that are likely to give trouble when the hay is fed. These hairs form the compact "hair balls" which sometimes form in the stomachs and intestines of animals fed with crimson clover. However, if cut fairly green there is little trouble from this source. It is also generally believed that it is better to feed only a part ration of crimson clover hay.

It is common practice, when crimson clover is intended for hay purposes, to mix it with winter wheat or winter oats, cutting and curing all together. The yield is not only much heavier, but thought by many to make a more desirable hay.

BURR CLOVER

The burr clovers (Fig. 179) are related to the alfalfas, and while they resemble them in the shape of the leaf, the burr clovers are all spreading, prostrate plants. There are both annual and perennial forms, but in general are adapted only to southern climates. The name is due to the seed pod, which is usually covered with short spines, giving the whole an appearance of burrs. There are two forms of burr clover commonly found in the United States, generally known as spotted burr clover, due to a dark blue purple spot on each leaflet, and toothed burr clover, from the dentate leaflets. Both of these burr clovers have become generally distributed through southern California, where they form quite an important natural herbage.

They are also more or less distributed through all the southern States. The cultivation of burr clover has never been extensive, partly due to the difficulty in harvesting the seed. The seed usually drops to the ground as soon as mature. In pure cultures, the burr clover is generally quite prostrate and it would be difficult to harvest in such a way as to save the seed.

Burr clover grows well during the winter months, and its greatest value is as a winter pasture plant or winter cover crop in the south-

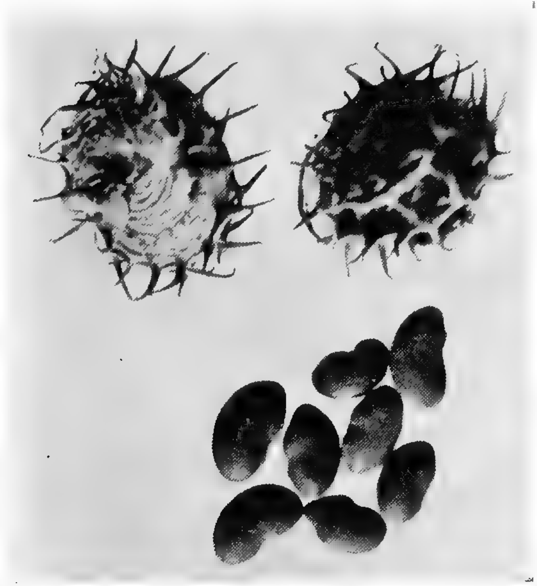

FIG. 179.—Seed pods and seeds of burr clover. (Enlarged.)

ern States. When once established, it reseeds so freely that it usually maintains itself without difficulty. The seed may be sown any time, but preferably in early fall. Burr clover is commonly recommended to sow as a pasture plant with Bermuda grass, as the Bermuda grass grows during the summer, but is dead during the winter. The burr clover, however, growing through the winter, furnishes a continuous pasture. The commercial supply of burr clover seed is limited at present, but better methods of harvesting and cleaning the seed are being developed as its use increases.

JAPAN CLOVER

Japan clover is a low-growing annual from east Asia. It is not known when or how it was introduced into the United States, but it was found growing more or less wild in Georgia as early as 1846. It has spread as a wild plant throughout all southern States north to Virginia and west to Texas.

Description.—Japan clover is an annual, growing six to eight inches high under ordinary conditions, but under very favorable conditions it sometimes reaches a height of twelve to fifteen inches. It is sensitive to frost and grows only during hot weather. It covers the ground with a thick, close mat of vine-like plants with minute blossoms and clover-like leaves.

Adaptations.—As a wild plant, Japan clover has not spread very much north of Virginia. The region where it seems to be best adapted as a cultivated crop is from Virginia southward. It grows on almost any well-drained soil, with remarkable ability to grow well on poor, sandy soil. It will also withstand considerable shade, which adapts it to lawn purposes. Japan clover has apparently reached its best development in the lower Mississippi Valley, where it is recognized as a forage plant of considerable value.

Culture.—The seeds of Japan clover normally ripen from about September, when they fall on the ground, but do not germinate until the warm weather of the following spring. It grows rapidly and soon covers the ground with a thick mat which begins to blossom in about two months and the seed crop is ripened in about four months. It usually seeds very abundantly. The seed can be sown any time during the winter months and is usually sown with winter grain. After harvest it takes possession of the ground and usually reseeds so abundantly that it is not necessary to sow it a second time if it is desired to keep the land in Japan clover.

Utilization.—Japan clover makes an excellent summer pasture, and is about the only legume well adapted to grow with Bermuda grass. A mixture of Bermuda grass and Japan clover with burr clover furnishes a year-round pasture in the South. While both Japan clover and burr clover are annuals, they reseed themselves so abundantly

that it is usually not necessary to sow them again. Japan clover is seldom cut for hay except on very rich land, as it is usually too low growing and the hay crop not large. On rich land, however, it will cut as high as two tons to the acre.

VELVET BEANS

The Florida velvet bean is a native plant of India, where several other species are found. It is a very large, strong-growing vine, sometimes reaching a length of thirty to forty feet. It requires a hot season and a long growing season of 200 days to mature. It is adapted only to Florida and the Gulf Coast.

The bean may be planted alone, when it forms a dense mass of vines, but usually produces few seeds. To secure a seed crop it should be supported on some upright plant, such as corn or sorghum. When planted alone, one plant every five feet each way is sufficient to cover the ground. It is most commonly grown with corn, however, with one plant about every five feet in the row. It is probably a better practice to alternate rows of velvet bean with corn at the rate of one row of velvet beans to three rows of corn.

The plant is so large that it is not practical to harvest the forage for hay. The best way to utilize is to turn the stock in and pasture it off.

FLORIDA BEGGAR WEED

Florida beggar weed is a native of the West Indies, but has been known in Florida since 1832. It is an erect plant, growing five to ten feet high. The seeds are borne in jointed pods, covered with short prickles, which break up at maturity and stick to anything with which they come in contact.

Florida beggar weed is adapted only to Florida and the Gulf Coast. It is considered valuable as a soil renovator, due to its large vigorous growth, but also makes an excellent hay if cut in bloom. Two crops a year may be harvested. The seed is sown alone in the spring at the rate of six to ten pounds per acre. It may also be sown with a cultivated crop, such as corn, and after the corn is harvested the beggar weed will develop a crop of either seed or forage.

QUESTIONS

1. State the importance of red clover, giving origin and early history.
2. Where is it grown in the United States?
3. Give its soil requirements.
4. Why is culture declining in some places?
5. Describe and compare mammoth and medium red clover.
6. Give methods of seeding red clover.
7. Is it generally sown alone or in mixtures?
8. Name fertilizers for clover.
9. Why is it suited to rotations?
10. Describe the roots.
11. State proportions of stems and leaves.
12. What is the best time to harvest red clover?
13. What is "brown hay"?
14. Give use for ensilage.
15. Describe pollination.
16. How is it grown for seed?
17. Give average yield of seed. How estimated?
18. State color of seeds.
19. What is clover sickness?
20. How important is inoculation?
21. Compare alsike and red clover in character of plant.
22. In climatic and soil adaptations.
23. Give its special use as forage crop.
24. Amount of seeds sown and common mixtures.
25. What is its value as a pasture plant?
26. Compare white clover with alsike clover and red clover as to character of plant and soil adaptation.
27. For what use is it best adapted?
28. State means by which it persists under pasture.
29. Compare the three types of sweet clover.
30. Describe its habits of growth.
31. What is the quality of sweet clover seed?
32. State time of sowing.
33. Where most cultivated, and why?
34. What are its soil requirements?
35. What gives it the sweet odor, and how does it affect the feeding value?
36. How important is inoculation?
37. Describe the crimson clover plant and soil adaptations.
38. Where most important as a cultivated crop?
39. How utilized as green manure?
40. Describe appearance of bur clovers.
41. Where is it found growing wild?
42. What are its principal uses?
43. Describe Japanese clover.
44. To what region is it best adapted?
45. Give its habits and growth. Culture.
46. What is its principal use?
47. Describe the Florida velvet bean and give method of culture.
48. Describe Florida beggar weed and methods of culture.

CHAPTER XLIII

COW PEAS, SOY BEANS, FIELD PEAS, VETCHES, PEANUTS

COW PEAS

Cow PEAS are much more closely related to the bean family than peas both in appearance and adaptation.

Cow peas are the most important leguminous crop south of the Ohio River. They are of tropical origin and require hot weather for best growth. They are also of great value as green manure because of their ability to grow on rather poor soil, and there is no crop in the South more important for building up impoverished land.

Origin and History.—Cow peas (Fig. 180) probably originated in tropical Africa, where the wild form is now found very commonly. They were extensively cultivated in ancient times, the seeds being used for human food and the vine for stock forage. However, since the introduction of the kidney bean from America, the use of cow peas as human food has declined. Cow peas seem to have been introduced into the United States at least by 1775, and were quite well known along the Atlantic Coast as far north as Virginia by 1800. From the first they have generally been cultivated for forage and green manure in the United States.

Classification.—The cow pea is extremely variable in character. Many varieties have a long, trailing vine and an indeterminate growth; that is, they continue to grow until killed by frost. Cow peas have been grouped in various ways, of which the following are examples:

1. According to habits of growth, as trailing, bushy, or erect.

2. According to the shape of the seed and pod. The common cow peas are known as kidneys, while another form, with long, slender pods in which the peas are closely crowded together, are known as "crowders."

3. According to time of ripening. Those that mature in from seventy to eighty days are known as early, from ninety to one hundred days as medium, and all that require more than one hundred

days as late. However, there are some tropical varieties that will not mature even in two hundred days.

4. Color of seeds is sometimes used in classification, but the variation is so great it is not satisfactory. Black, white, and red are the dominant colors, but most varieties are mixtures of these colors.

Best Known Varieties.—*Whippoorwill* is the oldest and best known variety of cow peas, and it is probable that half the acreage is

FIG. 180.—Cow peas in rows. Seed crop ready to harvest.

sown to this variety. It is seldom erect after much growth is attained. The *Iron* cow pea is of rather recent origin, being discovered in South Carolina in 1888. Its most important quality is resistance to both the wilt disease and root knot disease, and is recommended to grow wherever these diseases are common. *New Era* is a popular early variety of the bushy type. *Groit* is said to be the best variety for growing in the northern States. The last three varieties are more erect and are easily harvested for hay.

Adaptations.—Cow peas are of tropical origin and very sensitive to frost. They will not grow as far north as field peas, as they do very poorly in a climate where the nights are cool. In general, cow peas are less cultivated as we go farther northward from the Ohio River.

They are adapted to a very wide range of soils and show great ability to produce a crop on poor and unproductive soil. As they are a leguminous crop and capable of adding much nitrogen to the soil, they therefore become of great importance to the South as a crop to be grown on poor soils and turned under as a green manure crop.

Cow peas also do well on soils deficient in lime, which greatly increases their usefulness as soil restorative crops.

Culture.—Cow peas are sown in several ways, as broadcast in pure cultures; second, in rows spaced thirty to thirty-six inches apart; third, with standing corn and also sometimes mixed with other plants.

When sown alone, they are frequently sown broadcast or drilled at the rate of one to two bushels per acre. This is a common method when they are to be turned under for green manure.

It is also a common method when they are to be harvested for hay; while the yield of seed is not so large when sown broadcast as when planted in rows, yet considerable seed can be hand-picked before the crop is cut for hay.

Planting cow peas in rows about three feet apart is gaining in favor as a general practice. Usually about one peck of seed per acre is sufficient, and will require from two to three cultivations. When sown in rows, usually they produce a very much heavier seed crop than when sown broadcast, and in many cases will also produce a better forage crop.

It is also rather a common practice to grow cow peas with field corn. They may be drilled in at the same time that the corn is drilled, or their planting may be delayed until the last cultivation of the corn. They can then be sown broadcast between the corn rows, or a row drilled next to the corn rows. The latter method is probably the best. A fairly good seed crop can usually be harvested in this way, and the cow pea vines harvested with the corn fodder as forage.

Cow peas are occasionally sown with other forage crops, such as German millet or sorghum. By mixing in this way with another crop, it is found much easier to cure than pure cow pea forage.

Time of Sowing.—Cow peas, being hot-weather plants, should not be sown until the ground is well warmed in the spring, and there is no danger of frosts. In the southern States, planting may be continued from early spring up to August. Usually the earlier plantings produce a heavy growth of forage, while the later plantings produce the largest seed crop.

Inoculation for cow peas is very seldom required. While they will usually do better when the soil is well inoculated with the proper bacteria, it is very seldom that the crop will fail for lack of inocula-

Fig. 181.—Seeds of cow peas on left and soy beans on right.

tion. In fact, in some cases inoculation has shown very little benefit.

Harvesting.—Cow pea hay is quite difficult to cure, for the reason that the stems are large and dry very slowly, while the leaves are thin, dry rapidly, and are apt to be lost. It is usually considered best to wait until the first pods are ripened, or even a week or two later, as it is much more difficult to cure plants when very green than when they are partly mature. Many devices for drying out the hay have been invented by the growers, but in most cases it is best to cure the hay as well as possible in small shocks on the land, and then put up in very narrow stacks.

The yields of hay are extremely variable, depending on the climatic and soil conditions, but two to three tons per acre of cured hay are expected under fair conditions. The seed crop is even more

variable than the forage crop. Generally when conditions are favorable for developing a large growth of vine, the seed crop is small, while the best seed crop is ordinarily obtained when the weather is too dry or the soil a little too thin for the best forage crop. Under favorable conditions for a seed crop, twenty to thirty bushels per acre are harvested, but the yield will vary from this all the way down to nothing (Fig. 181).

Insects and Diseases.—Two species of weevil give a great deal of trouble by destroying the stored seed. These weevils lay their eggs on the pods, or when seeds are in storage directly on the seeds. The young larva hatches, finds its way into the seed, and finally matures into an adult in from twenty to thirty days. They continue reproducing until all the peas have been destroyed. The weevil can be destroyed by putting the seed in a tight room where the temperature can be raised to 130° F. for twenty minutes. Also the seed can be put into an air-tight bin and treated with carbon bisulfide. Carbon bisulfide should be put in a shallow pan and set on top of the seed, when it will quickly vaporize, and being heavier than air, the gas will soon fill all the spaces between the seeds. Two to three pounds of carbon bisulfide are required for each 1000 cubic feet of space.

The two most common diseases are root knot and wilt. The root knot is caused by a small nematode, and the wilt by a form of *fusarium* which attacks the roots. No remedy has been found except to grow disease-resistant varieties.

SOY BEANS

Soy beans (Figs. 182 and 183) are one of the oldest cultivated plants in eastern Asia, especially in Manchuria and Japan. They are one of the most productive legumes in seed, probably not being exceeded by any other, with the possible exception of field beans. In the Orient they are extensively used for human food, but in this country they have so far been cultivated principally for stock feed.

Origin and History.—A wild plant, closely related to the cultivated soy bean, is found growing throughout Japan and Manchuria, but differing from it in being a trailing vine, while the soy

bean is an upright, bushy plant. The cultivated soy bean is found in this same region and also China and north India. Here the beans are

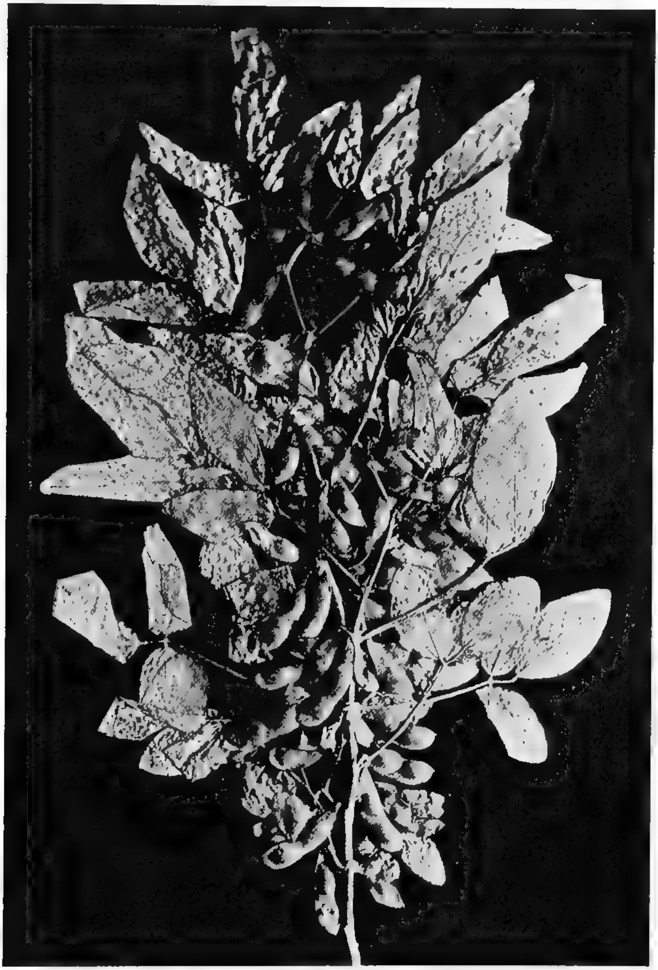

FIG. 182.—Soy bean plant.

used extensively as human food, and also for the manufacture of oil. At present not only the oil but the oil cake and great quantities of the beans are exported to Europe and America. The crop was intro-

duced into the United States as early as 1829, but received little attention until about 1890. It was the need of a drought-resistant legume for the western States that attracted most attention to soy beans between the years 1890 and 1900. Since 1900 some 300 varieties have been imported, mostly from Asia, and given trial in the United States.

Varieties.—The soy bean plant has a strong, upright habit of

Fig. 183.—Soy beans in rows three feet apart, for seed or forage.

growth, with little tendency to produce vines. It has a determinate growth, that is, the plant and seeds all ripen at the same time, in which it differs from the cow pea. The pods usually grow in thick clusters near the main stem. The height of the plant varies from eighteen inches to sixty inches, and varieties vary in maturing season from sixty to two hundred days. In all varieties the plant is decidedly hairy on the stem, leaves, and pods.

Soy beans have not been grown long enough so that all the best varieties are known to each region. South of the Ohio River to North Carolina it has generally been found that the large, rather late varieties are most productive. Of these the Mammoth, a late, large-growing variety, three to five feet tall, is the most popular. Hollybrook and Haberland, both one to two weeks earlier than Mammoth, are also grown to a less extent. A little north, or through the Ohio River valley, somewhat earlier varieties are required. Ito San and Pekin, both maturing in about one hundred and twenty days, are very satisfactory for this region. In the general region north of the Ohio River, and including most of the corn belt, the Wilson variety and the Guelph, also known as Medium Green, have given best results. Of the two, Guelph is probably better for forage.

Adaptations.—Soy beans, like cow peas, are hot-weather plants, and do rather poorly wherever either the days or nights are cool. The short growing season of early varieties, however, enables them to be grown profitably at least three hundred miles north of cow peas. While the cow pea region extends northward about the Ohio River, soy beans are profitably grown as far north as Ontario, Canada. While soy beans do well in humid climates, they are also remarkably drought-resistant, and it is their ability to produce a fair crop of seeds under the hot and rather dry summer climate of Kansas that first stimulated their culture in this country.

Soy beans, like cow peas, are adapted to a wide range of soils and are of special value, due to their ability to produce a fair crop on rather poor soils, especially soils of a sandy character. While soy beans are grown throughout the eastern half of the United States, they at present seem to have found a most important place in agriculture in about the same region as crimson clover, which might be roughly defined as lying between the red clover region on the north and the cow pea region on the south. They are of greatest importance from New Jersey and Maryland westward.

Description.—Soy beans are characterized by their stiff upright habit of growth, with little tendency to produce vines, except in a few varieties. They have a strictly determinate growth, that is, the plant and seeds ripen at the same time, in which they are very

different from cow peas that continue to grow and blossom until killed by frost. The soy bean blossoms are minute and borne in dense clusters near the main stem. The flower, like that of the cow pea, is strictly self-fertilized, and therefore is not at all like red clover, dependent on the agency of insects to produce seed. Soy beans are much more reliable in seed production than cow peas. With cow peas any condition of climate and soil that tends to produce a rank growth of foliage usually retards the seed production, but soy beans produce heavy crops of seeds under practically all soil and climatic conditions. In general, however, soy beans are less adapted to forage production than the cow peas.

Culture for Seed Production.—When soy beans are grown principally for the seed crop, they are usually planted in rows from two to four feet apart, depending on the size of the plant and convenience in cultivation. The smaller varieties, under two feet in height, will have plenty of room for full development if planted in rows two feet apart, and the plants two to three inches apart in the row, while the very largest varieties, such as Mammoth, should be planted in rows from three to four feet apart, and plants about three inches apart in the row.

Soy beans may be planted any time after the ground is well warmed up in the spring. The seed rots very easily if planted in cold soil. Ordinarily they should be planted a week or two weeks later than corn. When grown in rows, twenty to thirty pounds of seed per acre are sufficient. Clean culture must be practised until the pods are well set. Soy beans usually ripen quite uniformly, but generally the first pods are ripe from two to three weeks before the later ones mature. As the beans shell and drop to the ground quite easily when they ripen, it is the general custom to begin harvesting when the first pods begin to open. If harvested during damp weather, they can be cut and bound with a self-binder. If this machine is found to shell out too many beans, the next best method is to use the regular bean harvester. The beans should be cured in very small shocks in the field, handling them mostly on damp days or while the dew is on. The average yield is from fifteen to forty bushels to the acre, but maximum yields of forty to fifty bushels are sometimes secured.

Growing Soy Beans for Forage.—For forage, soy beans are grown in rows and cultivated (Fig. 183) or sown thickly with the grain drill. When grown in rows primarily for forage, they are planted about twice as thick as when grown for seed; that is, forty to sixty pounds of seed are required per acre. When broadcasted or sown thickly with the drill, from six to twelve pecks per acre are usually sown. It is best to cut them when the pods are well formed but not ripe, as the stems become quite woody as the plant matures. Soy beans are much easier to cure into hay than cow peas. For this reason, they are sometimes grown with cow peas as forage.

Mixed with Corn.—In the northern States where corn is used extensively for silage, many farmers now grow soy beans to mix with the corn in the silo. In some cases it is found best to grow the soy beans separately and mix the two as the silage is being cut, at the rate of about one load of soy beans forage to two loads of corn. In other cases, it has been found quite practical to grow the corn and soy beans together. If equal quantities of soy beans and corn be mixed in the corn planter box, a fairly even distribution can be secured, if the precaution is taken to keep them well mixed. There is some disadvantage in that the planting can not take place before the ground is well warmed, as soy beans will not do relatively as well as corn in cold, wet soil. Also there is a little more difficulty in giving clean cultivation to the corn, as the soy beans grow somewhat more slowly. If the corn is very thick and grows vigorously, it is also apt to smother out the soy beans. Some have found it more practical to plant the corn and soy beans separately at about the rate of two rows of corn to one row of soy beans.

The soy bean forage improves the silage by making it richer in protein matter. This mixture gives a well-balanced ration and reduces the feed bill for concentrated protein.

Inoculation.—While soy beans, like other legumes, have nodules and a particular form of bacteria associated with them, yet it is rare that they fail for lack of inoculation. They will usually do quite well on any productive soil, even when no trace of nodules can be found on the roots. It is probable, however, that inoculation is quite important on poor soils, especially if sandy. In experiments made

at the Michigan Station, it was found that plants grew quite well without inoculation, but the inoculated plants were found to be much richer in nitrogen. It is generally considered advisable to inoculate to secure best results.

Utilizing the Crop.—Soy bean seed is very rich in protein, usually carrying from twenty-five to thirty per cent. The ground soy bean meal is therefore an excellent protein concentrate to use in grain rations for live stock. The seed is also very rich in oil, and the manufacture of soy bean oil is an important industry in Manchuria. The oil can be used in the manufacture of paints and also for culinary purposes. The residue, after the oil is extracted, known as oil cake, is very rich in protein, and used for stock feed. In the Orient, the seeds are used extensively as human food, and also in the manufacture of the well-known suey sauce.

The forage cut green is easily cured into hay, although the hay is generally considered somewhat coarse. It is readily eaten by all kinds of stock and considered about as valuable as good clover or alfalfa hay.

FIELD PEAS

There is very little difference between what is known as the field pea and the common garden pea. The garden pea, however, usually has white flowers and light-colored seed, while many of the field peas have colored flowers and usually rather yellow seeds. Peas are found growing wild throughout the Mediterranean district, and seem to have been cultivated from very early times principally for human food. Field peas vary in height from two to five feet; the stem is weak, and if planted thin, the vines are usually prostrate on the ground. When field peas are sown thickly they usually cover the ground with a mass of vines from one to two feet deep.

Adaptations.—Field peas are all summer annuals, but are resistant to frosts and even light freezing. They can be grown as winter crops in regions where heavy freezing never occurs. In the region, however, where they are grown, they are always sown in the spring.

Field peas are very partial to cool summer weather, and are seldom grown south of New York State or Minnesota, except in

mountain valleys at high elevations. At present they are grown extensively in Canada, Wisconsin, and Michigan, and their culture is developing through the Rocky Mountain region to southern Colorado and also in the northwestern States.

Field peas grow on practically all types of soil, and are one of the best crops for heavy clay. While they do best on a limestone soil, yet they have a wide range of adaptation and will do well on soils quite deficient in lime.

Culture.—About a dozen varieties have attained importance. The most popular and best early varieties in Canada are Arthur,

Fig. 184.—Mixture of field peas with oats.

Golden Vine, and Chancellor. For medium to late, the Marrowfats and Prussian Blue.

Field peas are usually sown early, or at about the same time that ordinary spring grains are sown. Later sowings may be made for several weeks, but usually the best yield is secured from the earliest sowings. From one to three bushels of seed per acre are sown, according to size of seed and size of plant. The seed is large and should be covered two to three inches deep.

Mixtures.—Field peas are not generally sown alone, as the vines are so prostrate that it is difficult to harvest them. Also the yield

of field peas alone is generally not more than half as much as when sown with a cereal. It is generally agreed that oats are the best cereal with which to sow field peas (Fig. 184). Usually equal quantities by measure of oats and peas are sown, the total amount of the mixture varying from three to four bushels per acre.

The yield of cured forage, when sown alone, is usually about one to one and one-half tons per acre, but when mixed with oats, two to three tons per acre are expected. Other grains, such as barley and spring wheat, are sometimes used, but do not make so satisfactory a forage as the oats. Seed yields of field peas usually vary from twenty to forty bushels per acre, with maximum yields of about eighty bushels.

Utilization.—A mixture of field peas and oats is considered the best temporary forage crop for all the northern States and southern Canada. The forage is easily cured, and an excellent feed. The crop is sometimes put in the silo, but does not make as good a grade of silage as corn, as it is likely to be somewhat more acid. In the mountain valleys of Colorado, peas are used extensively as pasture to fatten sheep or hogs. The peas are sown and allowed to mature before the live stock is turned in. In Canada, oats and peas are very often threshed together, and the mixture makes an excellent grain for stock.

Pea Weevil.—The only serious enemy of the field pea crop is a small beetle known as the pea weevil. The eggs of this weevil are usually laid on the pods, where they hatch and the larva finds its way into the young peas. The larvæ grow to maturity in the pea and remain there until they emerge into full-grown insects. Only one brood is produced each year, and they do not attack mature peas. The beetles can be destroyed by storing the seed in tight sacks until they have all emerged and are starved to death. This usually means, however, holding the seed over an extra season. It is probably better to destroy the beetles by placing the seed in tight receptacles and treating with carbon bisulfide. When pea weevils become very injurious, it sometimes becomes necessary to discontinue the culture of peas for two or three years until the beetles have disappeared.

VETCHES

Wild vetches are very commonly distributed throughout the world, and botanists recognize at least 120 kinds. Several vetches have been brought into cultivation, but only two have received extensive culture, namely, the common or spring vetch or tares (*Vicia sativa*) and the hairy or winter vetch or sand vetch (*Vicia villosa*) (Fig. 185). Another member of the same family (*Vicia faba*) is never known as a vetch, but is usually called horse bean or Windsor bean.

Common vetch is an annual, but quite frost-resistant, and can be sown in the fall as a winter annual in all regions having a mild winter where only light freezing takes place. In more severe climates it is sown in early spring. It is a prostrate vine, usually three to five feet long, with tendrils at the ends of all the leaves, and purple flowers borne in pairs. It is found growing wild in southern Europe, and has probably been cultivated since the beginning of the Christian era.

Adaptations.—Spring vetch requires a cool climate and will not withstand the hot summer heat of the southern States. In the North it is sown in the spring, but in the southern States and on the Pacific Coast it is usually sown in the fall. It grows slowly during the fall and winter months, makes a rapid growth in the spring, and is usually harvested before the heat of summer. It is best adapted for culture where it can be fall sown, and in such climates is often preferred to the hairy vetch, as it is more productive. In the North, however, the hairy vetch is to be preferred, as spring vetch does not make sufficient yield when spring sown in the North.

Vetch can be grown in any well-drained soil, but has a preference for the lighter types. Vetch also has the merit of growing in soils quite low in lime content, which is a common fault of the poorer soils throughout the eastern part of the United States. Vetches are also better adapted to sandy soils than most of our cultivated plants.

Culture.—While several varieties of common vetch are recognized in Europe, we know little about the different varieties in America and generally recognize only the one. In this country we usually call it spring vetch in contrast with hairy vetch, which is

FIG. 185.—Hairy vetch.

designated as winter vetch, but this is not the case in Europe, where there are both winter and spring varieties of the common vetch.

Common vetch is usually sown in the fall either alone or with a

fall-sown grain crop. The time of sowing varies from September to November. When sown alone, about one bushel of seed per acre is required, but under unfavorable conditions this may be increased as high as two bushels per acre. In mixtures it is most commonly sown with oats at the rate of thirty to sixty pounds of vetch seed with equal weight of oats. The oats and vetch will mature at about the same time the following season, and can be cut together for forage or permitted to ripen and threshed together for grain.

Harvesting.—Vetch sown in pure culture is very difficult to harvest, as it forms a dense, viny mass not easy to separate. When allowed to ripen for the seed crop, it shells so easily that the horses or machinery should not run over the cut vetch. It is the general custom to have two men follow the mowing machine and roll the cut swath out of the way.

For hay or forage, it should be cut in full bloom. It is not at all difficult to cure, though some difficulty is experienced in handling it, due to its viny nature. It is for this reason that it is so commonly grown with a grain crop. The grain crop not only supports the vetch vines, making the crop much easier to handle and cure, but almost as good yields of vetch seed will be secured in the mixture as when sown alone.

Pasture.—Vetch makes an excellent winter pasture. If desired, the animals may be taken off in the spring and the crop harvested, or they may be continued on the pasture till midsummer. Vetch and burr clover probably make the two best winter pasture plants for the southern States.

Vetch makes an excellent cover crop, either to be plowed under as green manure or in orchards. It can usually be plowed under early enough in the spring to replant the land to another crop, such as corn or cotton.

Vetch seed (Fig. 186) is produced extensively in western Oregon. The average yield is about twelve bushels per acre, but yields of twenty to twenty-five bushels are not uncommon. At present about half of the seed used in this country is imported from Europe.

Hairy vetch is also known as Russian vetch, sand vetch, and in the United States very commonly as winter vetch. Hairy vetch is a

biennial or winter annual, making a slow growth the first year, but a rapid, heavy growth the second year, reaching maturity in the northern States during July. It is found growing wild throughout north Europe, where it was first brought into cultivation. Attention was first called to its culture in the United States about 1886.

Adaptations.—Hairy vetch is very hardy and is rarely known to winter-kill in northern United States or southern Canada. Hairy vetch will not do well under high summer temperatures, and is probably best adapted to the region north of the Ohio River, while common vetch is probably best for the southern States. Hairy vetch is

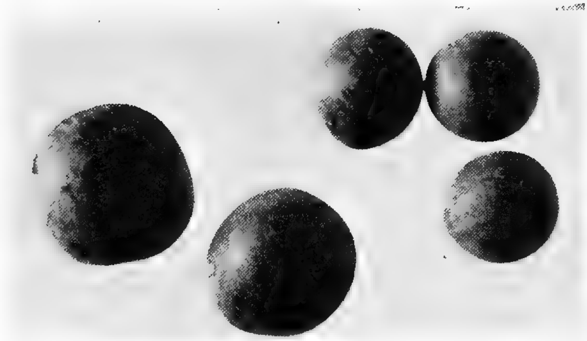

FIG. 186.—Seeds of common vetch on left, and hairy vetch on right (enlarged).

generally considered very drought-resistant, especially on sandy, coastal plain soils.

Hairy vetch grows well on practically all productive soils. Its success on sandy soils is well known and gives it the name of sand vetch. It is probably the best legume in the northern States as a restorative crop to be plowed under for green manure on sandy soils.

Culture.—Hairy vetch is commonly sown in the fall with rye or wheat, usually at the rate of about thirty pounds of vetch to one bushel of grain per acre. When sown alone, sixty pounds per acre are required. It is usually sown with grain because its heavy twining vines are difficult to harvest when sown alone. When sown with rye, it is comparatively easy to harvest with the rye, and after the two are threshed together, the seed of the vetch is separated out.

As a green manure crop, winter vetch is very commonly sown with rye, to be plowed under the following spring. It has also been found very practical to sow it with a spring grain like oats for the same purpose. After the oats are harvested, it makes a very good fall growth and comes on very early the next spring, in time to be plowed under for a cultivated crop, such as corn or potatoes.

Inoculation of the soil for vetch has not usually been found necessary. Natural inoculation seems to be present, probably due to wild vetches which are common in most cultivated soils. However, if no nodules can be found on the roots, it is considered best to inoculate to secure good yields.

Harvesting.—For forage purposes, vetch should be cut when in full bloom. For seed, it is allowed to become ripe and handled very much as common vetch. For seed purposes, it is very commonly sown with rye and the two harvested together. Average yields vary from six to ten bushels to the acre, with maximum yields of about twenty bushels.

Vetch seeds are quite commonly mixed and are difficult to tell apart. Hairy vetch seeds are smaller and very much darker in color than common vetch. Common vetch seeds are usually gray or somewhat mottled. The seed of common vetch, when crushed, has an orange-yellow color, while hairy vetch is a pale yellow.

Other Vetches.—The horse bean, or Windsor bean, is very different in appearance from the two vetches just described, and will not be taken as at all related by an ordinary observer. The horse bean is a strong, upright, coarse-growing plant, with large seeds half to three-quarters of an inch in diameter. The dwarf varieties usually grow about two feet high, and the large varieties about four feet high. Horse beans are grown only in a cool and humid summer climate. They will very seldom succeed well even in northern United States or southern Canada, but are extensively grown throughout northern Europe. The beans are used as human food, either cooked green or when mature, and also make an excellent stock feed to be mixed with cereals.

Narbonne vetch is found growing wild in southern Europe, re-

sembles somewhat the horse bean, and is thought by some to be the wild form. It is cultivated only to a limited extent.

Narrow-leaved vetch and purple vetch are similar to common vetch in their general characters. Both these vetches are little known, but are probably just as valuable as common vetch and adapted to about the same climate and soil conditions. They have given excellent results on the Pacific Coast.

Ervil or bitter vetch has long been cultivated in Europe and Asia. It is similar in habit to common vetch, and succeeds well in the South and on the Pacific Coast.

Woolly pod vetch is very similar in habits and character to hairy vetch, but is earlier maturing.

Vetch-like Plants.—Several species of the genus *Lathyrus* are cultivated in a limited way in Europe, and all have been found to grow well on the Pacific Coast. The *Tangier pea* is a tall growing annual, with beautiful flowers, frequently grown as an ornamental. The *Ochrus* is similar in habit, but has a peculiar foliage of flattened petioles and only a few true leaflets. The culture of both is similar to that of spring vetch.

PEANUT

The peanut (*Arachis hypogea*) belongs to the great group of plants known as legumes. It is one of the *Papilionaceæ* and is more closely related to the peas than any other legume. It could be more properly called ground pea than a peanut.

Origin and History of Peanuts.—It is generally believed that cultivated peanuts had their origin in South America, probably Brazil, although there is some evidence that there may have also been forms in Africa. It is generally believed, however, that the cultivated peanut was introduced from South America to Europe. Peanut culture began much earlier in the Old World, especially north Africa and India, than it did in the United States. Previous to the Civil War peanuts were cultivated in a small way in the South, principally in one district of Virginia. Since 1870, however, their culture has developed very rapidly, and almost doubled from the period 1899–1909.

Where Peanuts Are Grown.—At present peanuts are cultivated as a commercial crop a few hundred miles north of the cotton belt (Fig. 187). Eastern Virginia and North Carolina have always led in the cultivation of the crop, and these two States produce more than half the total crop in the United States. The following table

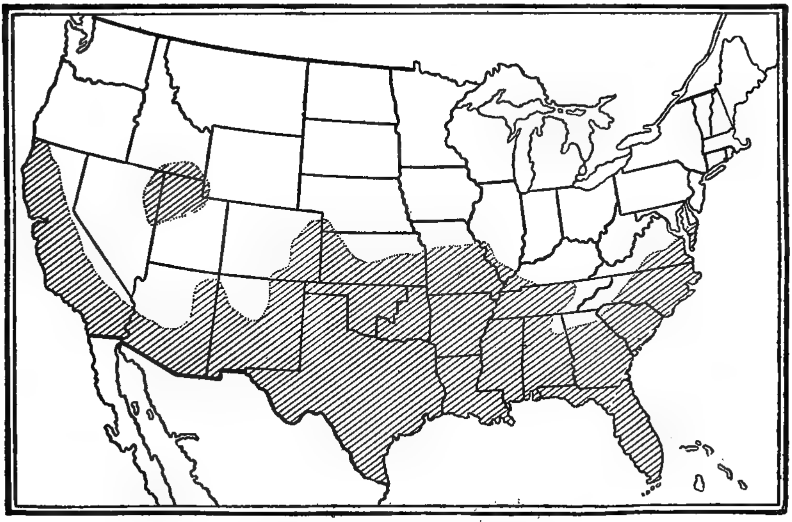

FIG. 187.—Map of the United States, showing the area adapted to the production of peanuts. (From Farmers' Bulletin 356.)

gives the production in bushels of the leading States and the per cent of increase during the ten years from 1899–1909:

Production of Peanuts in the United States

States	1909 *Bushels*	1899 *Bushels*	Increase *Per cent*
United States	19,415,816	11,964,109	62.3
North Carolina	5,980,919	3,460,439	72.8
Virginia	4,284,340	3,713,347	15.4
Georgia	2,569,787	1,435,775	79.0
Florida	2,315,089	967,927	139.0
Alabama	1,573,796	1,021,708	54.0
Texas	1,074,998	184,860	481.5

Description of the Plant.—The peanut plant is a vine, which may be long and prostrate in some varieties, or short and upright in

others (Fig. 188). The blossoms are borne in the leaf axils in the branches that lie on the ground. The flowers are small, yellow in color, each one borne on the end of a short stem. When the blossom has faded, the stem bends downward and begins to elongate, pushing the sharp-pointed ovary into the soil. If it is prevented for any

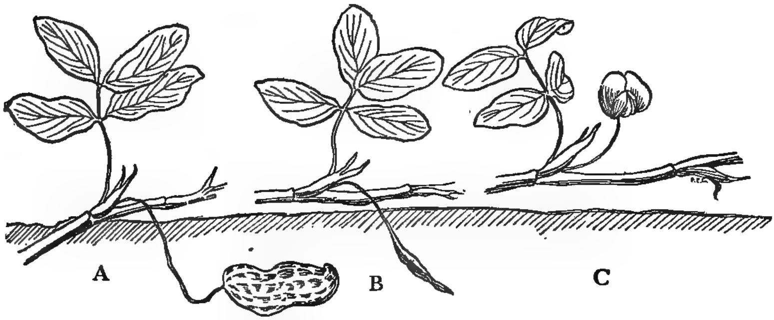

FIG. 188.—Three stages in development of the peanut: *C*, the blossom; *B*, the "peg" just entering the soil; *A*, the peanut pod.

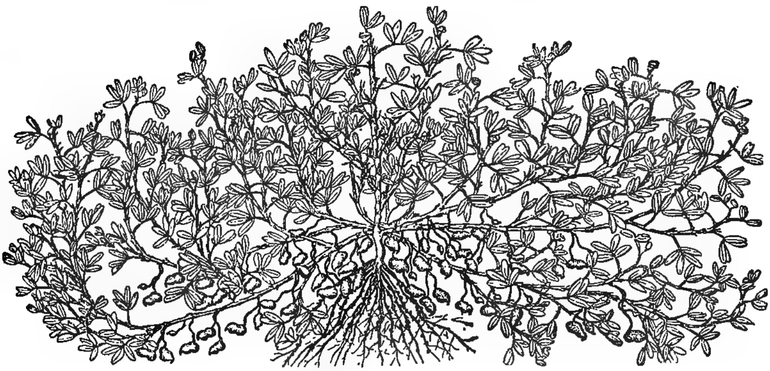

FIG. 189.—The peanut plant, Virginia running variety. (From U. S. Farmers' Bulletin 25.)

reason from entering the soil, the ovary withers and no pod will be produced. The pod usually bears two seeds, though in some varieties five or six are developed.

Classification of Varieties.—Only five or six common varieties are found in cultivation. Virginia Bunch and Virginia Runner (Fig. 189) are two very similar varieties, except the former is an

upright, short vine variety, and the latter has long, creeping stems. The bunch variety is the one most extensively cultivated. It is easier to cultivate the upright bunch form rather than the prostrate type, and also much easier to harvest, as the pods are clustered about the base of the plant, while in the Virginia Runner type the pods are scattered along the prostrate stem. In both varieties the pods are large, and the weight of a bushel is about twenty-two pounds.

North Carolina is a variety very similar to the Virginia Runner, but both the plant and the pod are somewhat smaller.

Spanish is a small-podded variety, with upright, bushy vines (Fig.

A B

FIG. 190.—Two types of peanuts: *A*, a large Virginia type; *B*, small Spanish type.

190). Spanish is the best variety to grow for forage on account of the upright vine, and is generally most productive in pods. It is probably the best variety to grow for shelled peanuts, but for peanuts roasted and sold in the pod, the larger varieties, such as Virginia, are preferred.

Tennessee Red is a small-podded variety similar to the Spanish, but the pods are longer and sometimes contain five or six peas. This is considered a very good variety to grow for stock feeding.

Composition of Peanuts.—The peanut, like most leguminous plants, is characterized by being very rich in protein matter. Peanuts are also extremely rich in oil, being exceeded in this respect by

very few plants. The following table gives the composition of peanuts in comparison with some other standard products:

Composition of Peanuts and Other Products

	Protein *Per cent*	Carbohydrates *Per cent*	Fats *Per cent*
Peanut hay	10–12	42–46	2–4
Peanut, whole plant	13–18	36–40	15–21
Peanut kernels	24–26	16–18	42–50
Corn meal	9–10	66–68	4–5
Cottonseed meal	40–42	22–24	13–14
Clover hay	12–13	35–45	2–4
Timothy hay	6–7	52–54	2–3

Climatic Requirements.—Peanuts, being a tropical plant, require a long growing season free from frost. The earlier varieties require from 100 to 120 days without frost, while the larger varieties, such as Virginia, require a month longer. The peanut is favored by bright, sunshiny weather and comparatively light rainfall during the growing season.

Soils for Peanuts.—Peanuts thrive on almost any soil type, ranging from light, sandy soil to clays. The light, sandy soils, however, are generally preferred for two reasons: It is easier to keep the surface in a mellow condition under the vines, and also the pods have a brighter and a cleaner appearance. The color of the pod, however, is only important in the case of peanuts to be sold on the market, but of no consequence where they are grown for stock feed or to be shelled. Good drainage is also necessary.

Fertilizers and Manures.—It is generally considered quite important to have sufficient lime present in the soil so there is no acidity. While the vines grow very well on a slightly acid soil, they do not usually set so good a crop of pods. The amount of lime required will vary from 500 to 1000 pounds per acre. It is best applied some weeks before planting. In natural limestone soils, of course no lime is required.

The most important mineral fertilizer for peanuts is phosphate, while potash is probably next in importance. Only a small quantity of nitrogen is needed, since the peanut is a legume and acquires its

nitrogen supply from the air. A good peanut fertilizer should contain two or three per cent available nitrogen, eight to ten per cent phosphate, and about six per cent potash. This is generally applied at the rate of 300 to 500 pounds per acre. Farmyard manures and green manures are not considered as important for the peanut crop as for many other crops. In fact, it is not considered desirable to add stable manure to land the same year the peanuts are grown, as it has a tendency to produce an overgrowth of tops and poorly filled pods. It is better to apply the stable manure to some previous crop.

Preparation of the Land.—It is important in growing peanuts to have the land free from weeds and weed seeds, as it is difficult to cultivate them closely, owing to their viny nature. Generally peanuts should follow a crop which has been given clean culture, such as corn or cotton.

In preparing the land, it should be first well plowed and fitted. It is the general custom then to open up furrows where the peanut rows are to go, and apply fertilizer in these rows. The fertilizer is then covered with a back furrow. Before planting the ridges are worked down with harrows or weeders until almost level. The peanuts are then planted about two inches deep in these ridges, directly over the fertilizer. The planting is generally done by machinery, though where grown on a small scale, hand planting is still practised. In some cases, especially on poor soil, late in the season, the ridges are not prepared, but the planting is done on level land.

Distance to Plant.—The Bunch varieties, such as the Virginia Bunch or Spanish Peanuts, are usually planted in rows from twenty-eight to thirty inches apart, but the larger varieties are planted about thirty-six inches apart. With the smaller varieties the plants are usually spaced six or eight inches in the row, or for the larger varieties, twelve inches apart. The planting of all varieties is closer together on poor soil than on rich soil. The amount of seed required is about two bushels per acre when planted in the pod, or about half a bushel per acre of shelled peas. Shelled peas are usually preferred, as they germinate quicker and more uniformly. The smaller varieties, such as Spanish, are very commonly planted in the pod, but the larger varieties, such as Virginia, are

usually shelled. The shelled seed is usually dropped much more uniformly by machinery than when planted in pods.

Time of Planting.—Peanuts, being rather sensitive to frost and cold soil, should not be planted until warm weather. This is usually soon after corn planting period. In Virginia the crop is generally planted in May, but somewhat earlier farther south. Early varieties of peanuts, such as the Spanish, can be planted up to the first of July, but the yield is usually correspondingly decreased if the planting is later than July first.

Method of Cultivation.—The method of cultivation for peanuts is very similar to cultivation for corn or cotton and practically the same tools are used. It is important to keep a loose mulch of soil under the vines, in order that the "pegs" or young pods may be easily pushed into the soil. It is the general custom to use rather narrow shovel cultivators for the early cultivation, and to "lay-by" by throwing a considerable ridge of loose soil about the plant.

HARVESTING

Time of Digging.—It is the general custom to dig peanuts before frost, in order to save the tops for stock feed. They are generally considered ready to dig whenever the pods nearest the base of the plant show a tendency to shed. Maturity is also shown by the leaves assuming a yellowish appearance. There will always be some green pods on the plant, but digging should take place when the majority are mature.

Methods of Digging.—Various means of digging or lifting the peanuts have been devised. A very common method is to remove the mould board from a common turning plow, and run the share underneath the peanut vine, cutting off the tap root and loosening the plants. The plants are then lifted with a fork and thrown into windrows, or smaller bunches.

The large horsepower potato diggers have been found very practical tools for lifting peanuts, and this is the most practical and desirable method where the acreage will justify it. Special machines are also in the market for digging and bunching the peanuts, some of which are very successful.

Curing the Peanuts.—Peanuts cure rather slowly, the process taking from four to six weeks. It is the custom to set up stakes about seven feet high, either in the field or in the stackyard. The stakes are usually sharpened at both ends and set firmly in the ground. Usually one or two cross-pieces are nailed near the ground to keep the peanuts from the soil and provide circulation of air. The peanut vines are then stacked about the pole with the pods inside, leaving as much air space as possible next to the pole. A few vines

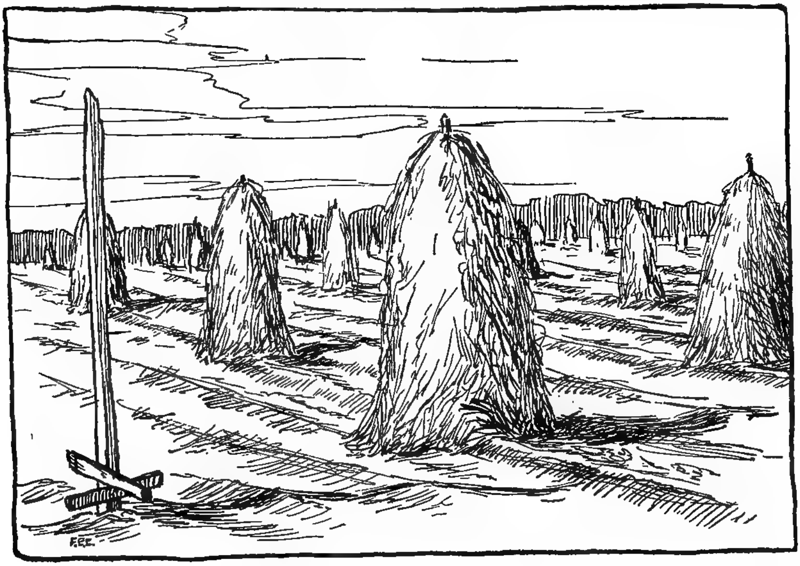

FIG. 191.—Method of shocking peanut crop, over a stake.

are, from time to time, thrown over the pole, in order to bind the shock together. The shock should be narrow, not more than four feet in diameter, and well capped to shed rain. The shocking should take place not more than twenty-four hours after lifting, as the pods will shrivel up if exposed too long.

Picking and Storing.—When the pods have been well cured, they are ready to be picked. Picking should always take place during dry weather, as the least moisture coming in contact with the pods will discolor them. In the past the pods have been generally

hand-picked, the work mostly done by women and children at a cost of from ten cents to twelve cents per bushel. Several machines are now on the market for picking, the better types of which do very satisfactory work. The greatest difficulty with machine-picking heretofore has been due to the cracking more or less of the pods. Cracking is especially serious when the peanuts are put in storage, as there are several insects which work on the peas if the pods are cracked.

Preparation for Market.—As the peas come from the machine or hands of the pickers, they contain considerable dirt and are usually covered with fine dust. They are usually cleaned by machinery, which scours and polishes the pods more or less. The cleaning and preparing for market is usually done at the warehouses and not by the growers. The large type of peanuts are usually graded and given special preparation to improve their appearance.

Shelled peanuts are used very extensively, and these are usually prepared also by special shelling machinery. The best grades of the large peanuts are usually sold in the pods, but the smaller peas are more commonly shelled.

Uses of the Peanut.—The peanut is gaining in importance as a food plant. They are prepared, either by roasting, to be sold in the pod, or after roasting they may be shelled, slightly salted, to be sold as salted peanuts. Peanut butter is also an important commercial product, and it is prepared by grinding the peanuts into a fine emulsion. Peanut butter, which is almost fifty per cent oil, has the advantage of retaining its quality without becoming rancid, and is adapted to a variety of uses.

Peanut oil is also manufactured very extensively, the crushed peanuts yielding about thirty per cent oil. It can be used as salad oil in place of olive oil, though it is not considered as good as the best grade of olive oil. Large quantities of peanut oil are produced in Marseilles, France, from peanuts largely imported from India or north Africa. After the oil is extracted, the peanut cake makes a valuable stock feed.

Peanuts as a Stock Feed.—It has long been the practice to turn hogs into the peanut field after harvest to gather up the pods that

have been left. They are now regularly cultivated in many places as feed for hogs, the animals being turned into the field to harvest the crop for themselves. Hogs fatten readily on peanuts, but should be corn-fed for some time before slaughter, as an exclusive diet of peanuts produces a rather soft quality of meat.

Peanut vines make an excellent quality of hay. As a hay crop peanuts should be planted somewhat thicker than common. The vines are cut with a mowing machine and cured like any other hay. A yield varying from one to two tons per acre, cured hay, is expected. Spanish peanuts are the favorite variety to grow for hay crop. Peanut straw, if the vines are well cured, makes a very fair stock feed, and is usually utilized for this purpose.

Insects and Diseases.—Peanuts are quite free from insect enemies. A small aphis sometimes works on the roots of the plant, but is not considered a very serious pest. The principal injury comes from insects that attack the peanut in storage; however, they can only attack those peanuts where the pods have been cracked, and their control is only a problem of storing sound peanuts. The only disease of importance is known as leaf spot and produces small brown spots on the leaves; however, it only gives trouble during very wet periods or on low, wet land. It is never known to give trouble under other conditions. The disease can be controlled by spraying with Bordeaux mixture.

LABORATORY EXERCISES

PEANUTS

1. If green plants or preserved material is available, make drawings of a stem, showing a blossom, "peg" and pod.

2. Determine the relative size by weight, and per cent of hull, in all the standard varieties you can secure.

3. Plant a few peanuts and make weekly observations on growth during the summer.

QUESTIONS

1. Tell the origin and history of the cow pea.
2. How are they classified?
3. What are the best known varieties?
4. Give the soil and climatic adaptations.
5. What are the principal cultural methods?
6. Give time of sowing and amount of seed.

7. Importance of inoculation.
8. What are the yields of hay and seed?
9. Name principal insect enemies and diseases.
10. Give the origin and history of the soy bean.
11. Name important characteristics.
12. What are best varieties for each region?
13. Give climatic and soil adaptations.
14. Compare with cow peas in character of plant.
15. Give methods of culture for seed. For forage.
16. Give mixtures with soy beans.
17. Why is it valuable to mix with corn silage?
18. Give importance of inoculation.
19. How is the crop utilized?
20. Describe field peas.
21. How do they compare with cow peas in climatic adaptations? In soil adaptation?
22. Name principal varieties.
23. Give time of sowing. Quantity of seed sown.
24. Give some common mixtures.
25. Why so often mixed with oats?
26. Give the life history of the pea weevil.
27. Name two principal types of cultivated vetch.
28. Describe spring vetch.
29. Where is spring vetch principally grown?
30. Give culture methods.
31. How is the seed crop harvested?
32. Where cut for hay or forage?
33. What is the pasture value of spring vetch?
34. How does winter vetch differ from spring vetch?
35. Where is winter vetch grown?
36. Give ordinary cultural methods.
37. How is it used as green manure crop?
38. Name common mixtures with winter vetch.
39. Describe the horse bean.
40. Name other cultivated vetches.
41. To what cultivated plants are peanuts related?
42. Relate the origin and history of the peanut.
43. Where are peanuts most extensively grown at present?
44. Describe the peanut plant, and especially the formation of the pod.
45. Describe briefly each of the important varieties.
46. How does the peanut compare with other common products in (1) protein; (2) carbohydrates; (3) fats?
47. Would you consider peanuts a rich food?
48. Why are light or sandy soils often preferred for peanuts?
49. Will they do well in loam or clay soils?
50. Why is lime often needed by peanuts?
51. Discuss the use of fertilizers. Of farmyard manures.
52. Describe a method of preparing land and applying fertilizer.
53. What is the ordinary distance of planting with small varieties? With large varieties?
54. How much seed is required in planting an acre?
55. When are peanuts planted?

56. How are peanuts cultivated?
57. How do you determine when peanuts are ready to dig? Describe methods of digging.
58. Describe the method of curing peanuts.
59. Why should picking take place during dry weather? How are they picked?
60. How are peanuts prepared for market?
61. What is peanut butter? Peanut oil?
62. How are peanuts utilized as stock feed?
63. What varieties are usually grown for stock feed?
64. Are peanuts subject to injury from insects or diseases? How is insect injury prevented?

CHAPTER XLIV

ROOT CROPS

Root crops are grown for human food, for the manufacture of sugar and as forage crops for stock feed.

Those grown for stock feed are classed as beets, turnips, carrots, and artichokes. Since cabbage, kale, and rape belong to the same family as turnips, are grown for stock feed, and the culture is similar, it is best to consider them all at the same time.

In England and north Europe root crops have long been important crops for feeding stock. In the United States they have never become important, only 19,000 acres of root forage being reported for the census year 1909, while in Canada 194,000 acres were reported. Their culture in the United States has been retarded for two reasons: (1) The relatively high cost of labor, as root crops require much hand labor, and (2) competition with corn and sorghum, both of which produce stock feed at much cheaper cost. In Europe roots have been regarded important as a winter succulent feed, but in the United States they will hardly compete with corn silage for this purpose, at least until labor is relatively much cheaper.

Root crops are more important in Canada, partly due to the less yield of corn, and probably in part due to a closer following of European customs in cattle feeding.

BEETS

The sugar beet holds first rank as a root crop, since about one-half of the world's sugar comes from this source, about six per cent of which comes from the United States.

The cultivated beets are usually classed into four groups:

1. Chard (grown for leaf stems).
2. Table beets (red flesh) (Fig. 192).
3. Mangel-wurzel (red and white flesh).
4. Sugar beets (white flesh).

The first two classes are grown only for culinary purposes, sugar

beets for sugar manufacture, though occasionally fed to stock, while mangel-wurzels are grown only for stock feed.

Root, Stem, and Crown.—The relation between root, stem, and the crown of leaves is most clearly understood by comparing a cabbage, kohl-rabi, and turnip as all belonging to the same family. In root crops the enlarged part is part root and part stem, the proportion of each varying in different varieties. The two parts can not be clearly distinguished, but it is probable that in the case of types deep set in the soil the enlarged portion is mostly true root, while in the case of those that grow largely above ground a higher proportion is enlarged stem.

Shape of Mangels.—The shape of mangels is designated as long (Fig. 193), half long, tankard, oval, or globe. The long and tankard shapes are most popular. These types usually stand about one-half out of ground, and are easy to harvest and handle.

FIG. 192.—Table beet, round form.

A good beet is not quite round in cross-section, but has a shallow depression on two sides. This depression is called a dimple. Fine fibrous roots should be limited to this depression. There should be no tendency for the root to divide at the tip or to have large roots coming out at other points. These points are especially important in sugar beets, as such beets are apt to be coarse, lower in sugar, and also difficult to clean.

Structure.—The beet is usually made up of five to seven alternate layers of tissue differing in density. In table beets all the tissue is a deep red. In mangels, the color is in the softer rings of tissue, while sugar beets are white throughout. The sugar content of beets is not uniform throughout, but they are poorest in the center, the sugar

increasing toward the outside and ends. The per cent of dry matter also follows the same principle, being greater near the outside. The same is true of potatoes, where the percentage of dry matter is generally about two lower in the center.

Composition.—All beets contain sugar. The commercial manufacture of sugar from beets was first developed by Napoleon in 1825. At that time beets contained only six per cent sugar, but since then by careful selection the sugar content has been increased to fourteen or sixteen per cent, and individual beets frequently yield above twenty per cent sugar. Stock beets usually contain six to eight per cent sugar.

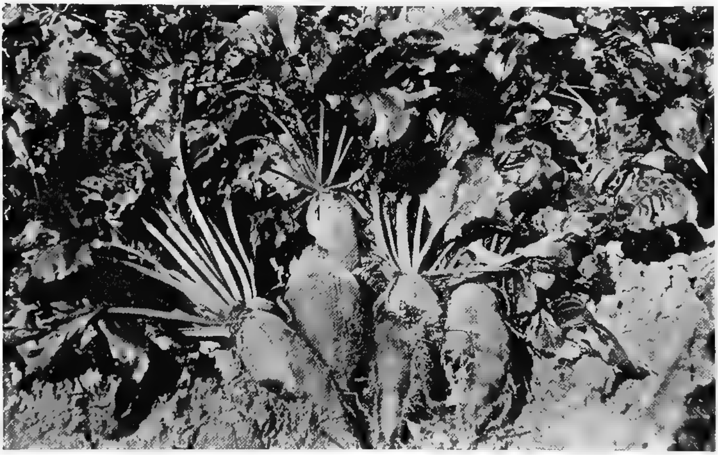

FIG. 193.—Mangel beets, long form.

Dry matter in stock beets ranges from ten to sixteen per cent, in comparison with potatoes containing sixteen to twenty per cent.

Preparation of Land.—Beets require rather deep fertile soils. It seldom pays to plant stock beets on any but rich soil, since the cost of growing, in seed, thinning, hoeing, and cultivating is so high that the crop must be large. For sugar beets the land should not be too rich in available nitrogen, as it will cause them to grow rank and be poor in quality.

Land is generally plowed deeper for beets than other crops, not

less than eight inches and often twelve to fourteen inches. It should then be thoroughly worked and pulverized, in order to insure a good stand and facilitate the careful hand-work necessary during the first six weeks with young beets.

Manure and Fertilizers.—For stock beets it is practical to make very heavy applications of manure, up to twenty tons per acre.

All root crops require relatively more potash than grain or grass crops. Fertilizers for roots are usually in the proportion of 4–8–6 to 4–8–10, applied at the rate of 400 to 600 pounds per acre.

Farmyard manure is best plowed under the fall before the land is planted to beets, but fertilizers are applied at the time the seeds are planted. Scattering 100 pounds nitrate of soda per acre, between the beet rows in midsummer, will greatly stimulate growth, but, in the case of sugar beets, injures quality.

Seeding.—The beet seed of commerce is a capsule containing one to five seeds. Each capsule will produce about two plants on the average. Beet seed is usually of good quality and retains vitality for several years. Mangels should stand seven to eight inches apart in the row and sugar beets five inches. From twelve to fifteen pounds of mangel seed per acre and eighteen to twenty pounds of sugar beet seed are generally used, in order to insure a full stand, although under ideal conditions half of this would be sufficient.

Seed is generally put in with a garden drill or grain drill, although special beet drills are used where grown on a large scale. The rows are usually twenty inches apart for sugar beets, and thirty to thirty-six inches for mangels.

Thinning.—When the plants have four leaves they are "bunched" with a narrow hoe, by chopping out the plants except in little bunches six inches apart. Soon afterward the plants are thinned by hand to one in a place. This is the hardest and most particular work connected with beet growing.

Cultivation.—A weeder or light harrow can be used several times after the beets are well started. After this thorough shallow cultivation with narrow tooth cultivators throughout the season. Usually from one to two hand hoeings are necessary, the first being given at time of thinning.

Harvesting.—Mangel beets can be pulled by hand, but sugar beets, being deeper in the soil, are more difficult to pull and are usually lifted with a beet puller. The tops are twisted off when beets are stored for stock feed, but in the case of sugar beets for the factory the crown is cut off. Beets can be kept in a cool cellar for three to four months, but they do not keep as well as turnips.

Fig. 194.—Kohl-rabi, belonging to cabbage family, but in this case the stem is enlarged, not the root as in turnips.

Yields.—Sugar beets usually yield from eight to fifteen tons per acre and mangels fifteen to thirty tons. Rutabaga is the only other root crop yielding as heavily as mangels. The yield of dry matter is from two to three tons per acre.

Feeding Value.—The dry matter of beets is considered to be pound for pound equal to grain. The succulence of beets also is valuable to animals on dry feed, especially dairy cows. Beets when first harvested have a very laxative effect, which, however, disappears when kept in storage for two months. Before feeding, beets are cut by hand or with a beet slicer.

TURNIPS

On the west and south coast of England and continental Europe is found a wild broad-leaved plant somewhat resembling a loose cabbage plant without a head, and known to botanists as *Brassica oleraceæ.* This plant under cultivation has shown remarkable variation, giving rise to a large number of cultivated plants. All parts of the plant have been modified, the leaves in cabbage, the flowers in cauliflower, the axillary buds in brussels sprouts, the stem in kohlrabi (Fig. 194), and the root in rutabagas (Fig. 195) and turnips.

Brassica oleraceæ.—Cabbage, cauliflower, broccoli, kohl-rabi, kale, brussels sprouts.

Brassica napus.—Rape.

Brassica campestris.—Rutabaga or Swede turnips.

Brassica rapa.—Common turnips.

There are also a number of hybrids between turnips and rutabagas, known as hybrid turnips.

Cabbage, kale, rape, rutabagas, and turnips are all grown for stock feed.

Comparison of Beets and Turnips.—Beets in general thrive

FIG. 195.—Rutabaga or Swede turnips.

under rather high summer temperatures, while the cabbage-turnip group require rather cool weather. Beets are sensitive to frost, while turnips all endure heavy frost, and some members of the group, as kale and collards, endure light freezing. Beets contain sugar, but there is none in turnips. Turnips are harder in texture, and keep longer in storage. Turnips in general do relatively better on light or poor soils than beets.

Culture.—Rutabagas and large turnips are sown in early summer, but the early flat turnips may be sown as late as August first, in the northern States. Turnips make their best growth during the

cool weather of fall and continue until freezing weather kills the tops. Early seedings should be drilled in rows, twenty to thirty inches apart, afterward thinned and given clean culture until late summer. Two to three pounds of seed per acre are required.

Early flat turnips sown in late summer are usually broadcasted on well-prepared land, and given no culture.

Rutabagas usually yield about as well as mangels, in northern climates, but where the summers are hot the mangles have an advantage. Flat turnips yield only half or two-thirds as much, but are quick growing and may often be sown as a catch crop late in the season.

RAPE

Rape is a large, broad-leaved plant from two to four feet high, and is well suited for temporary pasturage or soiling.

The form grown for forage is a biennial living over winter in mild climates, as the Pacific Coast. The principal cultivated variety is Dwarf Essex.

Rape is best adapted to a region of cool summers, and will endure heavy frost in the fall. Rape makes an excellent pasture for sheep or hogs, and for this purpose is best sown in drills twenty inches apart. The animals will walk between the drill rows and not tramp it out as when broadcast. Rape is frequently sown with small grain at the rate of three pounds per acre and harrowed in, but preferably after the grain is well started, as it will sometimes grow too fast for the grain. After harvest the rape makes a rapid growth and will furnish excellent fall pasture.

CARROTS

Carrots are about as productive as beets or turnips, but, being slower starting and smaller, require more care in early growth.

They may be classed according to color as red, orange, yellow, or white, while the roots vary from slender to short and thick, and may be either tapering or cylindrical. Carrots grow on any productive soil. The cultural methods are about the same as for beets or turnips.

QUESTIONS

1. Compare importance of root crops in America and Europe.
2. Why are they more important in Canada than in the United States?
3. Name the principal types of beet.
4. Define the root, stem and crown of beets.
5. Mention the principal shapes of the mangel.
6. Give structure and color of the beet root.
7. Give the composition of sugar beets; mangels: per cent of dry matter.
8. Give the soil requirements and preparation for beets; manure and fertilizers used.
9. Describe the character of the seeds.
10. Describe the planting, thinning and harvesting of beets.
11. Give the yield per acre.
12. Tell of their feeding value.
13. What other plants are closely related to turnips.
14. Compare beets and turnips in composition.
15. In climatic and soil adaptations.
16. Describe the culture for rape.

CHAPTER XLV

TOBACCO PRODUCTION

(By L. R. Neel, Editor *Southern Agriculturist*, Nashville, Tennessee)

Importance in America.—Tobacco, like Indian corn and the white or Irish potato, is a native of America. It was cultivated by the Indians at the time of the discovery and exploration of the country by the different European nations. It belongs to the nightshade family and has the generic name of "Nicotiana."

Tobacco is one of the great money crops of America. It is of much less importance than cotton, but the gross income to the farmer for the country per annum exceeds a hundred millions of dollars. In 1913, when conditions were normal, the crop was valued at $121,481,000 on the farms.

Where Tobacco is Grown.—Tobacco culture in a commercial way is confined to the humid part of the United States and largely to the eastern portion of this region. It is grown commercially all the way from Vermont and New Hampshire into Florida. Kentucky leads in the production of tobacco, North Carolina comes second, Virginia third, Ohio fourth, Tennessee fifth, Wisconsin sixth, Pennsylvania seventh, South Carolina eighth, and Connecticut ninth. Other States produce tobacco commercially, but in considerably smaller quantities.

The cigar types are grown in New England, New York, Pennsylvania, the Miami Valley of Ohio, Wisconsin, Georgia, and Florida. Chewing, smoking, snuff, and export types are grown in Kentucky, portions of southern Indiana and Illinois and eastern Ohio, part of Missouri, Tennessee, Maryland, the Virginias, and the Carolinas. Small acreages of tobacco mainly belonging to the latter type are grown in Alabama, Louisiana, Arkansas, and Texas.

Description of the Tobacco Plant.—Most of the tobacco in cultivation is derived from *Nicotiana tabacum*, the Virginia tobacco. It is a coarse, rank-growing annual. It has a simple, cylindrical stem that attains a height of from three to six feet or more in cultivation. The stem terminates in a panicle of pink or rose-colored flowers

with long corolla tubes. The leaves are simple and alternate. They are from a foot to two feet in length. The seeds are very small, a single plant often producing as many as 1,000,000. The whole of the green part of the plant is covered with long, soft hairs that exude a viscid juice and give the surface a moist, glutinous feeling.

Composition of the Tobacco Plant.—The tobacco plant is very rich in the plant food elements liable to be deficient in the soil. A crop yielding 1000 pounds of leaf per acre removes from the soil in stalk and leaf about sixty-seven pounds of nitrogen, eighty-five pounds of potash and nine pounds of phosphoric acid. Tobacco stalks are so rich in plant food that they make a valuable manure. They contain three to four per cent of nitrogen, four to five per cent of potash, and a fractional part of a per cent of phosphoric acid. The stems of the leaf contain from two to three per cent of nitrogen, six to ten per cent of potash and a fractional part of one per cent of phosphoric acid. The following table is taken from Bulletin 180 of the Connecticut Experiment Station:

Analysis of Fermented and Unfermented Tobacco Leaves

	A Upper Leaves		B Short Seconds		C First Wrappers	
	Unfer-mented	Fer-mented.	Unfer-mented	Fer-mented.	Unfer-mented.	
Water	23.50	23.40	27.40	21.10	27.50	24.90
Ash	14.89	15.27	22.85	25.25	15.84	16.22
Nicotine	2.50	1.79	.77	.50	1.26	1.14
Nitric acid (N_2O_5)	1.89	1.97	2.39	2.82	2.59	2.35
Ammonia (NH_3)	.67	.71	.16	.16	.33	.47
Other nitrogenous matters	12 19	13.31	6.69	6.81	11.31	11.62
Fiber	7.90	8.78	7.89	8.95	9.92	10.42
Starch	3.20	3.36	2.62	3.01	2.89	3.08
Other nitrogen-free extract	29.39	27.99	26.28	28.36	25.52	26.88
Ether extract	3.87	3.42	2.95	3.04	2.84	2.92
	100.00	100.00	100.00	100.00	100.00	100.00

Types and Varieties.—There are three general classes of tobacco. They are: (1) Cigar tobaccos, (2) export tobaccos, and (3) manufacturing tobaccos. By manufacturing tobaccos are meant

all kinds of tobaccos not used in cigars. The last two classes have so much in common that they are usually considered together.

In the cigar class are the three general types of wrapper leaf, binder leaf, and filler leaf. In the manufacturing and export tobacco are such kinds as dark fire-cured, Virginia sun-cured, flue-cured, and white Burley.

FIG. 196.—Tobacco plant developed for seed production. (Maryland Bulletin 188.)

Three important varieties or groups of varieties are used in growing cigar leaf tobacco in this country. They are the broad-leaf or seed-leaf group; the Cuban group, and the Havana seed group. There is an important group of so-called Spanish varieties that are practically like the Havana, if not identical with them. The Zimmer Spanish grown in the Miami Valley for a filler and the Comstock Spanish grown in Wisconsin for binder leaf belong to this group.

The principal varieties used in producing dark fire-cured tobacco are the Pryors, the Yellow Mammoth, and the Orinocos. These varieties and selections from them are used in producing the Virginia sun-cured tobacco. Such strains of these two varieties as Little Orinoco, Big Orinoco, Warne, Gooch, Adcock, Yellow Pryor, and Flannagan are used in producing flue-cured tobacco. White Burley is the variety used in producing the air-cured tobacco of the blue-grass region of Kentucky, Tennessee (to a limited extent), and in southern Ohio.

Tobacco Soils and Effect of Soil on Type.—In few if any crops does the soil have a greater influence on the quality of the product than tobacco. Tobacco of fine texture and mild flavor is produced on light, well-drained soils not too rich in organic matter, while the large yields of heavy and stronger tobacco are grown on the heavier and richer soils. The cigar wrapper tobacco is grown on the fine sands and sandy loam soils of the Connecticut Valley and Florida. In these soils the percentage of clay is low in both top and subsoil and they are not retentive of moisture. The binder-leaf soils of Wisconsin are sandy loams, light clay loams, and prairie soils which are dark rich loams. The cigar filler soil of the Lancaster district, Pennsylvania, is chiefly a limestone soil of the Hagerstown loam. It is a strong and moderately heavy soil. On the sandy loam soil of this district excellent wrapper leaf has been produced under shelter, showing how great is the influence of soil on type. Most of the tobacco grown in the Miami district is of the filler type, and the soil is designated as the Miami clay loam and the Miami black clay loam.

The typical soils used in growing flue-cured tobacco of Virginia and the Carolinas are light sands and sandy loams with yellow or red subsoils containing small proportions of clay. The white Burley tobacco reaches its highest development on the limestone blue-grass soils of central Kentucky. White oak, beech, walnut, maple, and hickory clearings are famous for the production of this tobacco. Blue-grass sod that has lain in pasture for ten or twenty years or more and on which stock have been fed to some extent produces good quality of Burley tobacco and gives good yields. The dark-tobacco soil of Tennessee and Kentucky is a heavy soil. A typical soil is derived from the St. Louis limestone and it is a silt loam. The soil is only moderately supplied with vegetable matter and is underlain by a very stiff and retentive clay. The Maryland tobacco, which resembles the cigar-leaf and the white Burley, is grown in southern Maryland on a silty or sandy soil gray or yellowish in color and usually deficient in vegetable matter.

Effect of the Crop on the Soil.—As suggested before, tobacco is very rich in plant food, and this means that it draws heavily on the

soil. It is not the most exhaustive crop, but is above the average. Where tobacco land is allowed to lie bare in winter the loss by leaching is likely to be greater than by the removal of plant food in the crop.

Fertilizers for Special Results.—The methods of fertilizing tobacco vary greatly with sections. A very considerable part of this difference is due to peculiar soil requirements, while more is due to special results required in the types. For some kinds of heavy tobacco the best grades are grown on the richest soils of the sections, as for instance the white Burley. In other grades, such as the lighter flue-cured tobacco of Virginia and the Carolinas, the best grades are produced on the lighter soils not too rich in vegetable matter. What is true of soils is also true of fertilizers. There is danger of using too high a percentage of nitrogen where a light, fine-textured tobacco is grown, while this element can be used very liberally in producing the heavy tobaccos adapted to the highly fertile soils.

Fertilizers for the Various Tobacco Regions.—In growing the Connecticut Havana seed tobacco on the typical sandy soil low in vegetable matter and under very expensive cultural methods, it is necessary to supply the soil abundantly with plant food. In the fall from ten to twenty tons of good stable manure should be plowed into the land, and in the spring it should be plowed again and the fertilizer applied broadcast. A ton per acre of a mixture containing about five per cent of nitrogen, five per cent of phosphoric acid and six per cent of potash is used. If the manure is not used the nitrogen content may be six per cent. The same fertilization is suitable for the Connecticut broad-leaf, but a somewhat heavier application can be made.

In Wisconsin, where the Comstock Spanish is grown for binder leaf, fertilizing with commercial fertilizer has not been so well worked out. Stable manure is used with good profit.

In the Lancaster, Pennsylvania, district, where the broad-leaf is grown as a filler, good rotation is practised and barnyard manure is used liberally, but the use of commercial fertilizer is not universally adopted and formulæ are not very definitely worked out.

Commercial fertilizer pays well in the Miami Valley of Ohio,

where the Zimmer Spanish variety is grown for filler. Good results are obtained in using as much as 1000 pounds per acre of a mixture analyzing nine per cent phosphoric acid, four per cent nitrogen and eight per cent potash. Stable manure gives good results, too.

The Cuban variety, which is grown mainly in southern Georgia and Florida for filler leaf, is fertilized heavily. The land should have fifteen to twenty loads of stable manure applied in the fall and should be plowed. A good fertilizer mixture to apply broadcast in the spring before setting the plants is 600 to 800 pounds of cottonseed meal, 400 pounds of acid phosphate, and 200 pounds of sulfate of potash per acre. This should be harrowed in the soil before marking off the rows.

White Burley tobacco is grown on the best land of the farm, as a rule, and is not fertilized. For this reason fertilizer formulæ are not well worked out.

In the dark tobacco district of Kentucky and Tennessee fertilizer is used rather generally, but in comparatively light applications. Frequently from 75 to 125 pounds per acre are dropped in the hills and this is all that is used. This may be a high-grade mixture, analyzing something like eight per cent of phosphoric acid, three or four per cent of nitrogen and six or eight per cent of potash. A mixture that has given very profitable results in the Clarksville district consists of 300 pounds high-grade acid phosphate, 400 pounds cottonseed meal and 50 pounds sulfate of potash. This is a good application per acre. It should all be spread broadcast and worked into the soil before marking off the rows. However, seventy-five pounds per acre in the hill are permissible and may be an advantage in starting the plants. Stable manure gives good results. Four to six tons per acre may be applied in the winter or early spring and plowed under as the land is being prepared.

Liberal applications of commercial fertilizer are used in producing the flue-cured tobacco of the Carolinas and Virginia. Where the soil is light and only moderately fertile a good formula is 500 pounds each of cottonseed meal and acid phosphate and 120 pounds of sulfate of potash.

The Maryland type is produced with light applications of commercial fertilizers. Stable manure gives good results.

Form of Potash to Use.—Sulfate of potash is generally used in tobacco fertilizers because the chlorine of muriate of potash has an injurious effect on the quality of the leaf. A good deal of muriate of potash is used in some sections, but recent results in Pennsylvania confirm the conviction that its use is hazardous, especially where fine quality is being produced.

Source of Nitrogen.—The growers of white Burley tobacco supply the nitrogen by clearing up new land or plowing up pastures that have never been broken or that have lain in white clover and blue-grass for many years, and by plowing under red clover sod. The legumes are used to take nitrogen from the air. This is the cheapest way, and as vegetable matter is also thus applied it is generally the best way. An exception might be in growing one of the light tobaccos that does best on soils low in vegetable matter. In the South cottonseed meal is used extensively as a source of nitrogen. Nitrate of soda is used more or less wherever fertilization is generally practised with tobacco. It is usually applied after the plants are set and have started to grow. A light application may be made before setting the plants to help start them off. Blood meal is used in many of the mixtures and tankage is employed in some sections in the tobacco fertilizer.

Source of Phosphoric Acid.—Acid phosphate is the common source of phosphoric acid for tobacco fertilizers. When tankage or bone meal is used to supply nitrogen it furnishes at least a part of the phosphoric acid.

Stalks and Stems.—Tobacco stalks and leaf stems are very rich manures. An application of one ton to two tons per acre makes a pretty liberal fertilization. A good way to apply where the season is long enough is in the fall on a crimson clover or rye and vetch crop that is to be plowed under for the tobacco the following year. As plant food is set free from the stalks the growing crop makes use of it and stores it for the tobacco. This should be plowed under some weeks before time to set the plants.

Breeding and Selecting Tobacco.—Some work has been done and is being done at crossing and hybridizing tobacco for improvement. This work, of course, belongs to the plant breeders and not the farmers.

The selection of seed plants for the production of seed for planting is a very important operation. It is simple and can be done by any intelligent farmer who is willing to take a little pains.

An excess of plants should be selected during the season and marked by tying a rag or a tag on them. They should come up to the ideal for stalk, leaf, and texture so far as this can be told in the growing season. A dozen plants may be enough on the small farm. About the time the flowers begin to open a twelve-pound paper bag should be tied over the flower head of the best plants; some of the inferior ones can be rejected. If any flowers have opened they should be cut off, because they have probably been cross-pollinated with an inferior plant. Every few days the bag should be raised to accommodate the lengthening stalk and the dead flowers should be removed to prevent mold. Insects that injure seed should be watched for. When the plants are mature they should be cut and housed, allowing the bags to remain on them. The leaves must be kept separate and compared so that the best seed plants can be selected. This method, kept up every year by a careful man, will result in a great improvement of the variety of tobacco.

The Plant Bed.—Tobacco plants are started in beds under favorable conditions from six to twelve weeks or even longer before time to set in the field. A sunny exposure is chosen and the soil should be well drained and warm. In some sections only new land is used for plant beds and no extra fertilization is given. In other sections very fertile blue-grass sod is plowed in the early fall to decay and make a seed bed the following spring. When old land has to be used manures and fertilizers are generally employed. Stable manure (it should be well rotted) is used at the rate of ten to twenty tons per acre, and rich commercial fertilizers are used at the rate of one to two tons per acre. The fertilizer is usually very rich in nitrogen. The Pennsylvania Station got best results in a test with forty-eight pounds of manure, four pounds cottonseed meal, one pound of acid phosphate, and one-half pound of sulfate of potash to 108 square feet of bed.

To kill weed seed and disease germs the plant bed is usually burned. This may be done by heaping wood on it and firing it, by

using a furnace or steam. The furnace used is on wheels and is placed on the bed. It is about 9 by 3 feet and has a pan that will hold dirt off that much space of ground to a depth of about two inches. Dirt is baked in it for an hour and then is returned where it came from. More dirt is taken up on the other side of the furnace. After this has baked an hour the machine is wheeled on, as the dirt underneath will have been sufficiently heated. In treating with steam an engine and a metal box are necessary (Fig. 197). Steam is forced in the box that is turned upside down on the bed

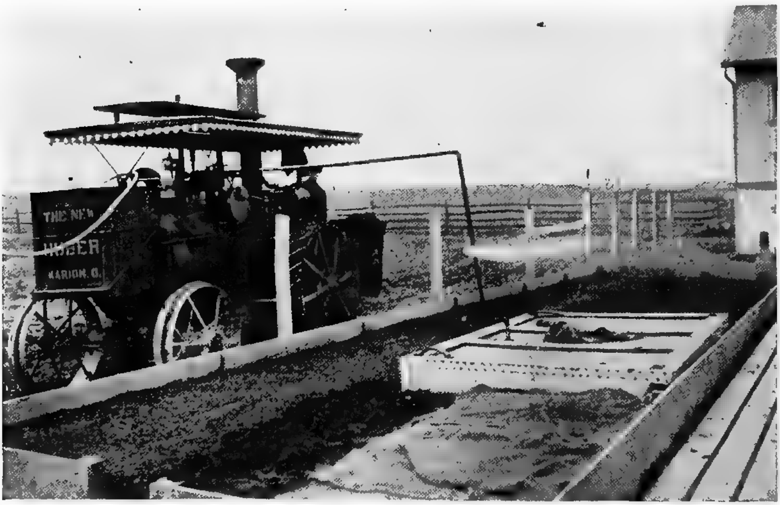

Fig. 197.—Sterilizing tobacco beds by steam. (Pennsylvania Bulletin 130.)

until the soil is heated to a temperature of 175° F. to a depth of four inches. This temperature should be maintained an hour. This form of treating tobacco beds has been most satisfactory. Sometimes logs are laid around the plant bed, which is usually six or eight feet wide, and in other cases boards are set up. A ditch should be opened around it and one should lead from this to afford good drainage. Cross-drains are sometimes needed. After burning, the soil is worked up with a plow or hand tools.

Sowing the Seed.—The rate of seeding varies greatly with the section. In some cases a teaspoonful of seed is sown to 100 square

feet, and in others that amount is sown on 200 or 300 square feet of bed. Sifted wood ashes, land plaster or some other diluent is mixed with the seed to aid in getting even distribution. It is then better to go over the land two or three times. Before sowing, the light seeds should be separated out and discarded by the use of a blower (Fig. 198). The seed are covered by tramping the land or going over with a roller.

After sowing the seed the bed should be covered with cheesecloth. In some of the more northern districts glass is sometimes used and the plants may even be grown in hot-beds.

The beds are watered frequently in dry weather, but not excessively, as this encourages fungous diseases. Sometimes to stimulate the growth of the plants nitrate of soda is used at the rate of one-quarter pound to ten gallons of water. The plants are sprinkled with this. It is a good idea to use clear water before and after using the solution to avoid any possible injury. If the stand is too thick, it may be necessary to thin, and if the bed was not burned or was not well burned, it will be necessary to weed.

FIG. 198.—Apparatus for separating light and heavy tobacco seed. (Devised by A. D. Shamel, U. S. Dept. of Agr.)

A week or ten days before time for taking the plants up, the cheesecloth or glass should be kept off some to harden them.

Preparing the Field.—If the danger of washing will not be increased, fall or winter plowing of tobacco land is frequently advisable. At any rate, early plowing should usually be practised to give vegetable matter time to decay and become available as plant food and to aid in the destruction of some of the insect pests. Where

cover crops are grown or even where clover is to be plowed under it may be best to let this stand until within a month or less of planting time to make more vegetable matter. However, when this is done the crop should be thoroughly disked before plowing, to hasten the decay of the green crop. The land should be thoroughly harrowed, disked, and rolled to make a fine and firm seedbed.

Distances of Planting.—The spacing of plants varies with the type of tobacco and the character of soil. The Connecticut Havana seed tobacco is grown in rows about three feet three inches or three feet six inches apart and fourteen to twenty inches in the row. The Connecticut broad-leaf is spaced twenty to twenty-four inches in rows somewhat wider than the Havana seed. The Wisconsin tobacco is grown in rows thirty-four to thirty-eight inches apart and is spaced in the rows eighteen to twenty-four inches. The Cuban variety is grown in rows three to three and one-half feet apart and is spaced fourteen inches in the row. The Pennsylvania broad-leaf is grown in rows three to four feet apart and is spaced in the rows eighteen to thirty inches. The Miami Valley tobacco is grown in rows thirty-four to thirty-six inches apart and is spaced twenty-two to twenty-eight inches in the row. The dark tobacco is usually grown in checks, the plants being about three and one-half feet apart each way. White Burley is grown in rows three and one-half feet apart and is spaced in the rows eighteen to twenty-four inches. Flue-cured tobacco is grown in rows three and one-half to four feet apart and is spaced in the row two to three feet apart. Maryland tobacco is grown in checks thirty-two to thirty-six inches apart each way.

Transplanting to the Field.—Machine planting is becoming more common. When the acreage justifies, the machine proves a good investment. It takes a driver and two persons to set the plants. It automatically waters and the skilled setter places the plant so as to get most benefit from this.

When hand setting is employed the rows are marked off, and then the places are usually marked in some way for the plants. A buggy wheel with the rim removed and the spoke spaces right may be run down the row to mark places for plants. When the tobacco is placed in checks, cross-rows have to be marked to indicate where the

plants go. An opening is made with a peg or dibble and the plant is inserted and the dirt firmed. If the soil is not moist enough, some water will have to be poured in each hole. It is better to set in cloudy weather and late in the day when this is practicable.

Seasons for Setting in Different Regions.—Tobacco is transplanted when the season gets warm so the plants will grow well without being stunted. In Florida this would be in March, in Georgia in April. In South Carolina planting begins in April, and runs through May and into early June in North Carolina and Virginia. In Tennessee and Kentucky planting begins in the latter part of May and should end in the first half of June. In Ohio transplanting is done in the first three weeks of June. In Pennsylvania and Wisconsin transplanting is done in June, the best time being not far from the middle of the month. In the Connecticut Valley the tobacco is set the last of May or early in June.

CARE OF THE GROWING CROP

Cultivation.—The cultivation of tobacco should begin soon after the plants are set, at least by the time they take root, and should be continued at frequent intervals so long as the growth of the plants will permit. It is often an advantage to cultivate rather deep early to let air down into the soil and warm it. In a droughty year this would be of doubtful value. After this the aim in cultivation should be to preserve a dust mulch and to prevent the growth of weeds. The hoe should be used just enough to keep the weeds down.

Topping.—The aim of the grower is to develop all good mature leaves as nearly as possible. To this end he removes the flower heads of the plants when enough leaves have formed. Another important reason for topping is that blooming and forming seed is exhausting to the plant and damages the quality of leaf. Only the plants that are to produce seed are allowed to bloom. Others are topped when enough leaves have formed, when the button of the bloom appears or when the plants begin to bloom. The practice varies with the section. However, it is pretty certain that nothing is gained in quality by allowing a plant to open its flowers before topping. The number of leaves varies with the purpose for which the tobacco is grown, the variety and the soil. Ten or twelve leaves

are as many as are ordinarily left to the plant in some regions, while in others as many as twenty may be left.

Suckering.—After the plant is topped it sends out suckers in the axils of the leaves. If these are allowed to grow they damage the quality of the leaf. Ordinarily these are removed soon after they form or when two to four inches long. Others appear after this and must be removed in time or they will injure the tobacco. It is customary to sucker only once in Wisconsin and that just before harvesting. This practice is not usual.

Priming.—Priming is the term applied to the removing of the lower leaves of the plant that are practically ruined by dragging in the soil and becoming dirty and frayed. Sometimes the priming is done at the time of topping. Bottom leaves are removed until those left are above danger of injury from the ground, and then the plant is topped until as many are left as it is desired to mature. In other cases the priming is done before or about the time of ripening.

Tobacco Rotations in Different Regions.—Strict rotation is followed no more closely with tobacco than with other farm crops. The crop often follows itself, and in other cases is just fitted in where it is handy or where it is thought a crop can be grown. The Virginia Experiment Station has done some valuable work in working out rotation for tobacco that keeps up the fertility of the land and at the same time produces good quality of leaf. One recommended for the sun-cured district is: First year, tobacco; second year, wheat; third and fourth year, grass; fifth year, corn with crimson clover cover crop; sixth year, cow peas; seventh year, red clover. The following year tobacco would be grown again. If wire worms and cut worms are bad the clover would be omitted and the tobacco would follow the peas.

The Virginia Station recommends the following rotation for dark and flue-cured tobaccos: First year, tobacco; second year, wheat; third, fourth, and probably fifth year, grass. Herd's grass seems to be one of the best crops to precede flue-cured tobacco.

In Pennsylvania some very good rotations are followed. A three year rotation is: (1) Wheat, (2) grass, (3) tobacco. This is made a four-year rotation by inserting corn between grass and tobacco.

A rotation that is followed in the dark tobacco district of Tennessee and Kentucky when clover will succeed is: (1) Tobacco, (2) wheat, (3) red clover. In the White Burley district of Kentucky, as already stated, the tobacco is put on new land, in a pasture that has never been broken or in one that has lain in sod for from ten to twenty years. When a good piece of land is put in tobacco it may be sown to rye to turn under in the spring, and tobacco may be planted a second time. After this wheat or rye is usually sown and the land is put back in grass. Other growers raise one crop of tobacco on blue-grass sod and then sow rye and blue-grasses and let the land run in sod then for a term of years.

Rotation is not followed systematically in Wisconsin. The station recommends that tobacco be grown three years in succession on a field and then that it be run in corn, barley, and clover for three years and then go back to tobacco. Another recommendation is that it run in tobacco four years and then run in corn, barley, clover, clover and grass, and then back in tobacco.

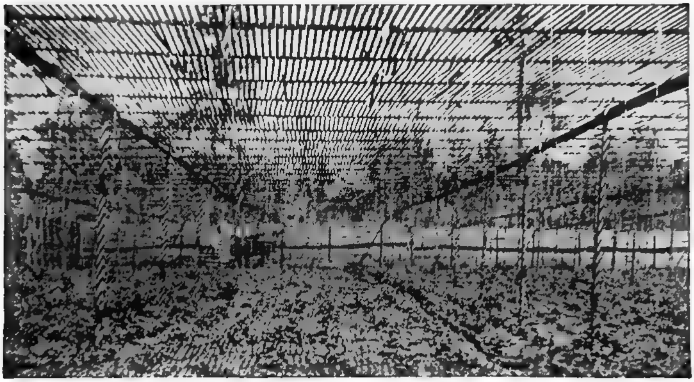

FIG. 199.—Cheesecloth shade for growing fine wrapper tobacco. (Davis's "Productive Farming.")

A rather common rotation where rotation is practised in Ohio is: Tobacco, wheat, grass. This is sometimes made a four-year rotation by following grass with corn and corn with tobacco.

Growing Tobacco Under Artificial Shade.—Some cigar wrapper tobacco is grown under artificial shade in Connecticut, Massachusetts, and Florida. Tents of cheesecloth are erected over the land on which the tobacco is grown (Fig. 199). Leaf of the finest quality

is thus produced, and it brings a price that makes the very expensive method of raising profitable.

HARVESTING THE CROP

Ripeness is indicated by the leaves taking on a yellowish tinge. It is noticeable on the bottom leaves first. The thickening leaf also has a leathery feel. Another test for some types is to turn up the under side of the leaf and fold between the fingers. If ripe it will snap or crack and retain the crease. In some regions the ripening of the leaves is uneven enough so that they are gathered separately as they ripen. Generally, however, the entire plant is harvested when the majority of the plants are at the best stage.

Fig. 200.—Frame for hauling tobacco to the barn, Wisconsin. (Courtesy Wisconsin Experiment Station.)

In some regions shears are used for cutting the stalks, in others a hatchet is used, some use corn cutters and others knives of different kinds. The plants are usually thrown with the butt end next to the sun. After wilting the tobacco is hung on sticks by spearing the stalks or by splitting them from the top to within six inches of the butt, and then placed on scaffolds and let stay outdoors for a few days or are taken directly to the barn. Worms and suckers are carefully removed as the crop is harvested (Fig. 200).

CURING THE CROP

Air Curing.—After the tobacco has wilted and probably yellowed somewhat on the scaffold it is taken to the barn and the sticks are hung on tier poles which are far enough apart horizontally to accom-

modate the stick and are far enough apart vertically so the tiers will not crowd each other.

Air is admitted freely through side ventilators. Top ventilators are provided for the part of the crop put there. In dry weather the ventilators are kept open day and night, but on damp nights they are closed (Fig. 201). In very dry weather it may be necessary to close the ventilators during the day and open at night to keep the tobacco from curing too fast. In damp, drizzly weather it may be better to keep the ventilators closed day and night until the tobacco begins to sweat, when ventilators had better be opened. If the trying weather

FIG. 201.—Barn for curing white Burley tobacco, Kentucky.

continues it may be necessary to make a fire under the tobacco of coke or charcoal.

Open Fire Curing.—In the dark tobacco districts the tobacco is hauled to the house after wilting or possibly after being placed on the scaffold to yellow to some extent and crowded closer together than in air curing. Very little regard is paid to ventilation in the barn. About five days after housing the yellowing process is completed and firing is begun. If indications of heating and consequent house burn occurs, firing should be started earlier. The fire is built on the ground directly under the tobacco. Slow fires are kept up for the first two or three days to continue the yellowing process. Hotter

fires are then kept up until the curing is practically completed. There is danger in curing too quickly. Some of the more careful growers fire for ten days.

Sometimes, after about a week's firing, the tobacco is allowed to sweat, when slow fires are added for a few days. Hickory and oak wood are preferable.

Flue-curing.—Yellow tobacco is cured at a higher temperature than the types mentioned. The barn has close walls. If they are of log the cracks are chinked and daubed or stopped with cement. A ventilator is provided at the top. Furnaces are built on one side and pipes lead from these across the house and then back and pass through the wall a few feet higher than the level at which they left the furnace. A vertical pipe carries the smoke off.

The tobacco is allowed to wilt to the right stage and is then hung in the house. The first tier of poles is pretty high off the ground, nine feet being a common height. The barn should be filled in one day and a thermometer hung about the center of the barn on the lower tier. A moderate fire is started and maintained until the leaf is thoroughly yellowed, which usually takes twenty-four to thirty-six hours. During this process the barn is kept tight. A temperature of from 80° to 120° F. is maintained, beginning at the lower temperature and running up to the higher. The next thing to do is to remove moisture, which is the most critical part of the curing. A temperature of from 130° to 140° F. is maintained until the leaf is dry. Close attention has to be paid to the ventilation to keep the moisture just right. After the moisture is gone the ventilators are closed down and the temperature is run up to 165° to 170° F. at the rate of about five degrees an hour. This temperature is maintained until all stems are dry (Fig. 202).

Stripping, Sorting, and Tying.—After tobacco is cured it is let hang until the conditions get right for the absorption of moisture, when the leaves become pliable and may be handled without breaking. Some growers have a damping cellar where some of the tobacco can be hung to come in the right order for handling. During cold weather tobacco may be bulked down and covered after it gets in the proper condition for handling and kept that way for some time. During bulking tobacco may improve in quality.

Tobacco must be handled only while in a pliable condition or it will crumble and ruin. It is stripped, unless it was stripped in harvesting, and graded. The number of grades varies with the kinds of tobacco. Length of leaf, freedom from injuries, texture, curing, and other points determine the grade. Practical experience only will enable one to learn to grade tobacco.

As tobacco is stripped and sorted it is tied into hanks. A hank

FIG. 202.—Barn for curing dark tobacco, Tennessee.

is a bunch of several leaves. The tie is made at the butts of the leaves with a leaf.

Storing.—The stripping and tying may take place so late in the season that the tobacco may be taken to market almost immediately afterwards. In some instances it is put into cases, tied into bales or prized into hogsheads, while still a larger part is marketed loose in the hanks. While in storage it usually ferments and the quality is thus improved if conditions are favorable.

Marketing.—Tobacco is mainly marketed individually. Some

co-operative associations have been formed and sell the tobacco of members, but this affects only a small part of the crop.

The tobacco of Virginia and the Carolinas is sold by the auction sales system. Large loose-leaf warehouses are provided in centers. Here the farmers bring the crop. It is placed in charge of the warehouse, is weighed and tagged with owner's name and is piled on the floor. Buyers can inspect freely as the auction goes on. As piles are sold, the owners are credited with the amount due and the buyers' wagons remove the tobacco. The State requires that the scales be standardized and that weighings and all transactions be honestly conducted.

In the Baltimore market the State guarantees samples and has State inspection. The samples of the farmers' tobacco are taken in charge by commission men and they and the buyer trade. Sometimes the farmer fixes a minimum price.

Lexington, Kentucky, has loose-leaf auction sales and handles an immense amount of tobacco. In some other markets auction sales are conducted, but the buying is done by sample. Only these are exhibited in the salesroom.

In other markets, like Clarksville, Tennessee, and Hopkinsville, Kentucky, most of the tobacco is sold from the wagon by the farmer. The buyers may bid on it, but this is done privately. If a co-operative association handles the tobacco, its salesman takes samples of each farmer's tobacco and sets the price at which it shall sell.

Yields and Prices.—For the ten-year period, 1900–1909, the average yields and prices were as follows:

State	Pounds per acre	Cents per pound
Connecticut	1657	16.4
Pennsylvania	1331	8.6
Maryland	634	6.5
Virginia	717	7.8
North Carolina	622	8.8
Florida	722	31.4
Ohio	875	8.6
Wisconsin	1278	8.6
Kentucky	833	7.5
Tennessee	734	7.3

INSECT ENEMIES

Tobacco Horn Worm.—The tobacco horn worm is the worst insect pest of the crop. If left alone it will usually completely ruin the tobacco. A combination of hand-picking and arsenic poisons is the practical means of control (Fig. 203). When the infestation

is light hand-picking may be the most practical. It is usually advisable to begin early, before the worms become abundant. It is often necessary, too, late in the season, after spraying is stopped. Arsenate of lead paste used at the rate of four pounds to fifty gallons of water makes an effective spray. However, it is more practical to use the powdered arsenate of lead in a dust form. Mr. A. C. Morgan, of the U. S. Bureau of Entomology, finds that this can be

FIG. 203.—The Northern Tobacco Worm or Horn Worm. (*a*) moth; (*b*) larva; (*c*) pupa (after Howard). The tobacco worms appear in large numbers during certain years. Several methods may be practised to control the pests. (Wisconsin Bulletin 237.)

applied best when mixed with equal part of sifted wood ashes. This must be applied with a powerful dust gun and when it is calm. Three and a half to five pounds of arsenate of lead per acre are thus used. The arsenate of lead sticks better than Paris green and does not injure the tobacco, while Paris green is liable to do so. Fall plowing helps in the control of the horn worm.

Cutworms.—The cutworm often makes it hard to get a stand

of tobacco. When the land is badly infested with this insect late planting, preceded by over a month of absolutely clean culture to keep all vegetation down, is often advisable. It may be necessary to poison some clover by wetting it with Paris green at the rate of one ounce to six gallons of water and scattering this clover at intervals of six to eight feet late in the evening so that the worms will get it during the night while fresh.

Wireworms.—The eggs of wireworms are deposited by the parent moth in weedy fields in July and August and the larvæ that hatch remain in the ground over winter. Clean culture to prevent the growth of the weeds practically eliminates the wireworm the following year. Cow peas or soy beans grown in rows and cultivated the summer before tobacco is planted practically insure no damage from tobacco wireworms.

Budworms.—The budworm is combated by applying Paris green mixed with corn meal at the rate of a tablespoonful to a peck of meal. This mixture is applied in the bud during the time of attack two or three times a week.

The Splitworm.—This worm is the larva of a very small moth. The worm acts as a leaf miner and does considerable damage to the crop where numerous. It is not generally serious yet. As a remedial measure it is suggested that the crop be put out as early as practicable; if the early infestation is serious, take off infested leaves and destroy. When the crop is removed plow the land and clean up as thoroughly as possible to get rid of the wintering insects. Do not follow potatoes with tobacco, and remove the potato field as far from tobacco as possible.

Tobacco Thrips.— This minute insect feeds on the surface of tobacco leaves and thus causes a lighter color that may reduce the selling price at least fifty per cent. As it is particularly injurious to shade tobacco, the loss is very great.

The adult appears to pass the winter in the tobacco field. For this reason rotation of crops and fall plowing of tobacco land and cleaning up rubbish would offer some relief. The practice of locating the plant bed in the field is bad. As the pest breeds in oats, this crop should not be near the tobacco. Kerosene emulsion is effective against thrips. It should be used first when the plants are in the plant bed. After they are removed to the field two sprayings a week are advisable. Spraying may be needed for as long as ten weeks.

FUNGOUS DISEASES

Bed-rot or Damping Off.—The rotting of young plants in the plant bed is usually spoken of as damping off. It starts at or near the surface of the ground. Planting in new soil may avoid the trouble, and the various methods of treating the plant bed to kill weed seed also destroy the fungus. Steaming is especially valuable for killing fungous diseases, but roasting or surface firing should be effective, too. Spraying with formalin, 1 to 50, will kill the fungous spores if done before planting the seed. After the disease is started the only way to stop it is to take off cheesecloth and thus lower the temperature, and to limit the water so conditions will be unfavorable to its development. Thinning the plants to admit air will also help.

Root Rot or Black Root.—This disease attacks roots of the plants both in the bed and in the field, causing them to turn brown or black. It can be controlled in the plant bed by the means suggested for damping off, but the only practical remedy in the field is to rotate and have clean soil to set the clean plants in.

Brown and White Rusts.—This disease is characterized by the death of small spots in the leaves. These may run together and cause a considerable part of the leaf to shrivel up. It seems to be due to a number of conditions. Excess of water, of certain fertilizing material or of manure, deep cultivation, insufficient moisture at certain stages, moist weather succeeded by hot weather, drops of dew acting as a lens focusing the sun's rays may cause the brown or white rusts. No practical method of control can be suggested. However, tobacco should not be planted in fields known to produce the disease.

Mosaic Disease or Calico.—This disease is characterized by the mottled appearance of the leaf due to the presence of the light green and dark green areas. In pronounced cases the leaf may be wrinkled or corrugated.

No parasite has thus far been found associated with the disease, but it seems to be able to perpetuate itself. Plant beds should not be placed where the disease has been bad before. When only a few diseased plants occur they should be taken up and destroyed. When the disease is likely to occur planting on poorly drained soil should be avoided. The disease may be transmitted from one plant to another in suckering and topping. For this reason the healthy plants should not be topped by the same person at the same time as the diseased plants.

Shed Burn or Pole Rot.—Shed burn or pole rot occurs in the house. Sometimes it never develops beyond small dark spots on the curing leaf, and in other cases it may involve the entire leaf and may in extreme cases destroy the house of tobacco.

It is controlled by the proper regulation of temperature and humidity of the air. It does not develop below 60° F. nor in air where the humidity is below 85° F. As the temperature is raised the humidity must be kept at the proper stage or loss will follow. This is often difficult in air curing.

Stem Rot.—Stem rot is a fungous disease that attacks the stem in the house. It is controlled by regulating heat and moisture.

Wet Butts or Fat Stem.—This disease is characterized by wet, discolored and soggy condition of the stem during curing. It may extend to the leaf veins. Late tobacco is more likely to be attacked. Open fires to dry the air will usually check the trouble.

Black Rot in Sweating.—Black rot in sweating is recognized by dark brown or black color instead of the normal color of the cured leaf. It loses texture and develops its own peculiar odor that is detected by any tobacco man. It grows best in a temperature of about 100°. To avoid trouble the tobacco should be cured out before freezing weather. Forced sweating that raises the temperature to 113° will prevent black rot. If the moisture is low enough the disease will not develop.

White Vein Disease.—In this disease the veins assume a whitened appearance. It occurs in drying weather. It may be prevented by sprinkling water on the floor to keep up the humidity of the air.

Molds or Rusts.—White molds or mustiness occurs to some extent on fermenting tobacco. It may be controlled by the methods suggested under black rot in sweating.

LABORATORY EXERCISES

1. Examine tobacco soils in laboratory.
2. Separate large and small tobacco seed.
3. Study types of cured leaf.
4. Examine and use spraying machines.
5. Make a mixture of arsenate of lead and ashes for poisoning horn worms.

FIELD STUDIES

1. Study tobacco soils in neighborhood.
2. Study growing tobacco plants.
3. Visit tobacco plant beds.

4. Compare methods of sterilizing beds.
5. Learn rate of seeding.
6. Investigate distances of planting crop.
7. Study methods of transplanting.
8. Study local practice as to topping, suckering, priming and controlling insect pests.
9. Study local rotations.
10. Study houses and housing.
11. Study local method of curing.
12. Study method of stripping, grading, tying, storing and marketing.
13. Investigate yields and prices in the neighborhood.
14. Study insect pests and fungous diseases.

QUESTIONS

1. Name the important tobacco States in order of production.
2. Give botanical name of tobacco.
3. Name three general classes of tobacco.
4. Name three types of cigar tobacco.
5. Name three variety groups of cigar leaf tobacco.
6. Name principal variety groups used in producing dark and flue-cured tobaccos.
7. Name variety of tobacco produced in the blue-grass section of Kentucky.
8. On what kinds of soil are the leading types of tobacco produced?
9. Give fertilizer formulæ or analyses for the different districts.
10. Give form of potash to use.
11. Name some sources of nitrogen for the tobacco crop.
12. Name some sources of phosphoric acid.
13. Give a method of using tobacco stalks on tobacco land.
14. Give location of plant bed, fertilization, methods of sterilizing and preparing for planting.
15. Give method of sowing tobacco seed, and rate of seeding.
16. Give after-care of bed.
17. Give preparation of field for tobacco.
18. Give distances of planting in different sections.
19. Give methods of transplanting to field.
20. Give seasons for transplanting in different sections.
21. Give cultivation of crop.
22. Why is topping important and how and when done?
23. When is suckering done and why is it important?
24. What is priming and when is it done?
25. Give rotations for different sections.
26. In what States is tobacco grown under shade?
27. How is ripeness of the crop indicated?
28. How is the crop harvested?
29. Give method of air-curing.
30. Give method of flue-curing.
31. Give method of open-fire curing.
32. Discuss stripping, sorting, tying and storing.
33. Give methods of marketing tobacco in different sections.
34. Give some yields per acre and prices per pound.
35. Name important insect enemies and give methods of control.
36. Name important fungous diseases and give methods of control.

APPENDIX I

Legal Weights Per Bushel of Seeds [1]

State or territory	Barley	Beans	Blue-grass	Broom corn	Buckwheat	Castor beans	Clover	Corn in ear	Corn in ear, unshucked	Corn, shelled	Cotton, Sea Island	Cotton, upland	Cow peas	English blue-grass	Flax	Hemp
Alabama	47	60						70	75	56		32				
Arizona	45	*a*60								54						
Arkansas	48	*b*60	14	48	52		60	70	74	56		33⅓			56	
California	50				40					52						
Colorado	48	60	14		52		60	70		56						44
Connecticut	48	60			48		60			56	44	30			55	
Delaware										56						
Florida	48	60				48			70	56	46	32				
Georgia	47	*b*60	14		52		60	70		56		30			56	44
Idaho	48				42		60			56					56	
Illinois	48	*b*60	14		52	46	60	70		56					56	44
Indiana	48	60	14		50	46	60	*c*70		56						44
Iowa	48	60	14	30	52	46	60	70		56					56	44
Kansas	48	60	14		50	46	60	70		56				22	56	44
Kentucky	47	*b*60	14		56	45	60	*d*70		56				14	56	44
Louisiana	32									56						
Maine	48	62			48					56						
Maryland																
Massachusetts	48	60			48		60			56	44	30			55	
Michigan	48	60	14		48	46	60	70		56					56	44
Minnesota	48	60	14	57	50		60	70		56						50
Mississippi	48	*b*60	14		48	46	60	72		56		32			56	44
Missouri	48	60	14		52	46	60	70		56		33			56	44
Montana	48	60	14		52		60	70		56					56	44
Nebraska	48	*b*60	14		52	46	60	70		56					56	44
New Hampshire		62								56						
New Jersey	48	60			50		64			56					55	
New York	48	60			48		60			56	44	30			55	
North Carolina	48				50		60			56		30			55	
North Dakota	48	60		30	42		60	70		56					56	
Ohio	48	60			50		60	68		56					56	44
Oklahoma	48	60		30	42		60	70		56					56	
Oregon	46				42		60			56						
Pennsylvania	47				48		60			56						
Rhode Island	48	60			48	46	60	70		56	44	30			56	44
South Carolina											42	30				
South Dakota	48	60		30	42		60	70		56					56	
Tennessee	48	60	14	42	50	46	60	70	74	56		28			56	44
Texas	48	*b*60			42		60	70	72	56		32			56	44
Vermont	48	62			48		60			56						
Virginia	48	*b*60	14		52		60	70		56		32	60		56	44
Washington	48				42		60			56					56	
West Virginia	48	60			52		60			56					56	
Wisconsin	48	60			50		60			56	44	30			56	44

[1] *Experiment Station Work*, Vol. II, No. 15. Compiled from Bulletin 51, United States Department of Agriculture, Bureau of Plant Industry.

a Small white beans 60 pounds, other beans 55.

b White beans.

c From harvest to December 1, 70 pounds; after December 1, 68 pounds.

d From November 1 to May 1, 70 pounds; from May 1 to November 1, 68 pounds.

Legal Weights Per Bushel of Seeds (Continued)

State or territory	Herd's grass	Hungarian grass	Italian rye-grass	Millet	Oats	Orchard-grass	Osage orange	Peanuts	Peas	Rape	Redtop	Rice, rough	Rye	Sorghum	Soy beans	Timothy	Velvet beans, in hull	Wheat
Alabama					32				60				56					60
Arizona					32								56					60
Arkansas				50	32	14			60		14		56	50		60		60
California					32								54					60
Colorado					32								56			45		60
Connecticut	45				32				60			45	56			45		60
Delaware																		60
Florida				50	32			22					56	56			78	60
Georgia					32				60			43	56			45		60
Idaho					36								56					60
Illinois					32								56			45		60
Indiana				50	32	14	33						56			45		60
Iowa		50		50	32		32						56	30		45		60
Kansas		50		50	32								56	56		45		60
Kentucky		50		50	32	14			60				56			45		60
Louisiana					32								32					60
Maine	45				32				60									60
Maryland					26													
Massachusetts	45				32				60			45	56		58	45		60
Michigan		50		50	32	14	33		60		14		56			45		60
Minnesota		48		48	32	14			60	50	14		56	57		45		60
Mississippi		50		50	32				60				56	42		45		60
Missouri		48		50	32	14	36		60		14		56	42		45		60
Montana		50			32				60				56			45		60
Nebraska		50		50	32		32		60				56	30		45		60
New Hampshire					32				60				56					60
New Jersey					30				60				56					60
New York	45				32				6C			45	56			45		60
North Carolina					32				60			44	56					60
North Dakota				50	32				60				56			42		60
Ohio		50		50	32				60				56			45		60
Oklahoma					32				60				56			42		60
Oregon					32								56					60
Pennsylvania					32								56					60
Rhode Island		50		50	32				60				56			45		60
South Carolina																		
South Dakota					32				60				56			42		60
Tennessee		48	20	50	32	14	33	23	60		14		56	50		45		60
Texas		48		50	32								56			45		60
Vermont	45				32				60				56			45		60
Virginia		48		50	30	14	34	22			12		56			45		60
Washington					32								56					60
West Virginia					32								56			45		60
Wisconsin		48		50	32				60	50		45	56			45		60

Weights of miscellaneous seeds not included in the table: Amber cane, New Jersey, 57 pounds per bushel; beggar weed, Florida, 62 pounds; canary seed, Tennessee, 60 pounds; hickory nuts, Tennessee, 50 pounds; Indian wheat, Vermont, 46 pounds; Japanese barnyard millet, Massachusetts, 35 pounds; Johnson grass, Arkansas, 28 pounds; Kaffir corn, Kansas, 56 pounds; pop-corn in ear, Indiana, 70 pounds; Ohio, 42 pounds; Tennessee, 70 pounds; pop-corn, shelled, Kansas, 56 pounds; spelt, North Dakota, 48 pounds; velvet grass, Tennessee, 7 pounds; walnuts, Tennessee, 50 pounds.

APPENDIX II

II. MARKET GRADES OF HAY AND STRAW

HAY

No. 1 Timothy Hay.—Shall be timothy, with not more than one-eighth ($\frac{1}{8}$) mixed with clover or other tame grasses, may contain some brown blades, properly cured, good color, sound and well baled.

No. 2 Timothy Hay.—Shall be timothy, not good enough for No. 1, not over one-fourth ($\frac{1}{4}$) mixed with clover or other tame grasses, fair color, sound and well baled.

No. 3 Timothy Hay.—Shall include all timothy not good enough for other grades, sound and reasonably well baled.

Light Clover Mixed Hay.—Shall be timothy mixed with clover. The clover mixture not over one-third ($\frac{1}{3}$), properly cured, sound, good color and well baled.

No. 1 Clover Mixed Hay.—Shall be timothy and clover mixed, with at least one-half ($\frac{1}{2}$) timothy, good color, sound and well baled.

No. 2 Clover Mixed Hay.—Shall be timothy and clover mixed, with at least one-fourth ($\frac{1}{4}$) timothy, reasonably sound and well baled.

No. 1 Clover Hay.—Shall be medium clover, not over one-twentieth ($\frac{1}{20}$) other grasses, properly cured, sound and well baled.

No. 2 Clover Hay.—Shall be clover, sound and reasonably well baled, not good enough for No. 1.

Sample Hay.—Shall be sound, reasonably well baled, mixed, grassy, threshed or hay not covered by other grades.

No Grade Hay.—Shall include all hay, musty, or in any way unsound.

Choice Prairie Hay.—Shall be upland hay of bright, natural color, well cured, sweet, sound, and may contain 3 per cent weeds.

No. 1 Prairie Hay.—Shall be upland and may contain one-quarter midland, both of good color, well cured, sweet, sound, and may contain 8 per cent weeds.

No. 2 Prairie Hay.—Shall be upland, of fair color, and may contain one-half midland, both of good color, well cured, sweet, sound, and may contain 12½ per cent weeds.

No. 3 Prairie Hay.—Shall include hay not good enough for other grades and not caked.

No. 1 Midland Hay.—Shall be midland hay of good color, well cured, sweet, sound, and may contain 3 per cent weeds.

No. 2 Midland Hay.—Shall be of fair color, or slough hay of good color, and may contain 12½ per cent of weeds.

Packing Hay.—Shall include all wild hay not good enough for other grades and not caked.

Sample Prairie Hay.—Shall include all hay not good enough for other grades.

ALFALFA

Choice Alfalfa.—Shall be reasonably fine leafy alfalfa of bright green color, properly cured, sound, sweet, and well baled.

No. 1 Alfalfa.—Shall be reasonably coarse alfalfa, of a bright green color, or reasonably fine leafy alfalfa of a good color and may contain 2 per cent of foreign grasses, 5 per cent of air bleached hay on outside of bale allowed, but must be sound and well baled.

Standard Alfalfa.—May be of green color, of coarse or medium texture, and may contain 5 per cent foreign matter; or it may be of green color, of coarse or medium texture, 20 per cent bleached and 2 per cent foreign matter; or it may be of greenish cast, of fine stem and clinging foliage, and may contain 5 per cent foreign matter. All to be sound, sweet and well baled.

No. 2 Alfalfa.—Shall be any sound, sweet and well-baled alfalfa, not good enough for standard, and may contain 10 per cent foreign matter.

No. 3 Alfalfa.—May contain 25 per cent stack spotted hay, but must be dry and not contain more than 8 per cent of foreign matter; or it may be of green color and may contain 50 per cent of foreign matter; or it may be set alfalfa and may contain 5 per cent foreign matter. All to be reasonably well baled.

No Grade Alfalfa.—Shall include all alfalfa not good enough for No. 3.

STRAW

Baled straw is abundantly sold in the large markets.

No. 1 Straight Rye-Straw.—Shall be in large bales, clean, bright, long rye-straw, pressed in bundles, sound and well baled.

No. 2 Straight Rye-Straw.—Shall be in large bales, long rye-straw, pressed in bundles, sound and well baled, not good enough for No. 1.

No. 1 Tangled Rye-Straw.—Shall be reasonably clean rye-straw, good color, sound and well baled.

No. 2 Tangled Rye-Straw.—Shall be reasonably clean, may be some stained, but not good enough for No. 1.

No. 1 Wheat-Straw.—Shall be reasonably clean wheat-straw, sound and well baled.

No. 2 Wheat-Straw.—Shall be reasonably clean; may be some stained, but not good enough for No. 1.

No. 1 Oat-Straw.—Shall be reasonably clean oat-straw, sound and well baled.

No. 2 Oat-Straw.—Shall be reasonably clean; may be some stained, but not good enough for No. 1.

APPENDIX III

GRADES OF GRAIN

Here are given the grades of grain adopted by the Grain Dealers' National Association at the 13th Annual Convention held in Indianapolis, October 6, 7, 8, 1909, together with the grades for corn adopted by the United States Government and effective July 1, 1914. Reported by Charles Quinn, Secretary, Grain Dealers' National Association, Toledo, Ohio.

WHITE WINTER WHEAT

No. 1 White Winter Wheat.—Shall include all varieties of pure, soft, white winter wheat, sound, plump, dry, sweet and clean, and weigh not less than 58 pounds to the measured bushel.

No. 2 White Winter Wheat.—Shall include all varieties of soft, white winter wheat, dry, sound and clean, and shall not contain more than 8 per cent of soft red winter wheat, and weigh not less than 56 pounds to the measured bushel.

No. 3 White Winter Wheat.—Shall include all varieties of soft, white winter wheat. It may contain 5 per cent of damaged grains other than skin-burnt wheat and may contain 10 per cent of soft, red winter wheat, and weigh not less than 53 pounds to the measured bushel.

No. 4 White Winter Wheat.—Shall include all varieties of soft, white winter wheat not fit for a higher grade in consequence of being poor quality, damp, musty or dirty, and shall not contain more than 10 per cent of soft, red winter wheat, and weigh not less than 50 pounds to the measured bushel.

RED WINTER WHEAT

No. 1 Red Winter Wheat.—Shall be pure, soft, red winter wheat of both light and dark colors, sound, sweet, plump and well cleaned, and weigh not less than 60 pounds to the measured bushel.

No. 2 Red Winter Wheat.—Shall be soft, red winter wheat of both light and dark colors, sound, sweet and clean, shall not contain more than 5 per cent of white winter wheat, and weigh not less than 58 pounds to the measured bushel.

No. 3 Red Winter Wheat.—Shall be sound, soft, red winter wheat not clean or plump enough for No. 2, shall not contain more than 8 per cent of white winter wheat, and weigh not less than 55 pounds to the measured bushel.

No. 4 Red Winter Wheat.—Shall be soft, red winter wheat, shall contain not more than 8 per cent of white winter wheat. It may be damp, musty or dirty, but must be cool, and weigh not less than 50 pounds to the measured bushel.

HARD WINTER WHEAT

No. 1 Hard Winter Wheat.—Shall include all varieties of pure, hard winter wheat, sound, plump, dry, sweet and well cleaned, and weigh not less than 61 pounds to the measured bushel.

No. 2 Hard Winter Wheat.—Shall include all varieties of hard winter wheat of both light and dark colors, dry, sound, sweet and clean, and weigh not less than 59 pounds to the measured bushel.

No. 3 Hard Winter Wheat.—Shall include all varieties of hard winter wheat of both light and dark colors, not clean or plump enough for No. 2, and weigh not less than 56 pounds to the measured bushel.

No. 4 Hard Winter Wheat.—Shall include all varieties of hard winter wheat of both light and dark colors. It may be damp, musty or dirty and weigh not less than 50 pounds to the measured bushel.

NORTHERN SPRING WHEAT

No. 1 Hard Spring Wheat.—Shall be sound, bright, sweet, clean, and consist of over 50 per cent of the hard Scotch Fife, and weigh not less than 58 pounds to the measured bushel.

No. 1 Northern Spring Wheat.—Must be Northern grown spring wheat, sound, clean, and of good milling quality, and must not contain less than 50 per cent of the hard varieties of spring wheat, and weigh not less than 57 pounds to the measured bushel.

No. 2 Northern Spring Wheat.—Shall be Northern grown spring wheat, not clean enough or sound enough for No. 1, and must contain not less than 50 per cent of the hard varieties of spring wheat, and must weigh not less than 56 pounds to the measured bushel.

No. 3 Northern Spring Wheat.—Shall be composed of inferior shrunken Northern grown spring wheat, and weigh not less than 54 pounds to the measured bushel, and must contain not less than 50 per cent of the hard varieties of spring wheat.

No. 4 Northern Spring Wheat.—Shall include all inferior Northern grown spring wheat that is badly shrunken or damaged and must contain not less than 50 per cent of the hard varieties of spring wheat, and shall weigh not less than 49 pounds to the measured bushel.

SPRING WHEAT

No. 1 Spring Wheat.—Shall be sound, plump and well cleaned, and weigh not less than 59 pounds to the measured bushel.

No. 2 Spring Wheat.—Shall be sound, clean, of a good milling quality and weigh not less than 57½ pounds to the measured bushel.

No. 3 Spring Wheat.—Shall include all inferior, shrunken or dirty spring wheat, and weigh not less than 53 pounds to the measured bushel.

No. 4 Spring Wheat.—Shall include all spring wheat damp, musty, grown, badly bleached, or from any cause which renders it unfit for No. 3, and weigh not less than 49 pounds to the measured bushel.

WHITE SPRING WHEAT

White Spring Wheat.—The grades of Nos. 1, 2, 3 and 4 White Spring Wheat shall correspond with the grades of Nos. 1, 2, 3 and 4 Spring Wheat, except that they shall be of the white variety.

DURUM (MACARONI) WHEAT

No. 1 Durum Wheat.—Shall be bright, sound, dry, well cleaned and be composed of durum, commonly known as macaroni wheat, and weigh not less than 60 pounds to the measured bushel.

No. 2 Durum Wheat.—Shall be dry, clean and of good milling quality. It shall include all durum wheat that for any reason is not suitable for No. 1 durum, and weigh not less than 58 pounds to the measured bushel.

No. 3 Durum Wheat.—Shall include all durum wheat bleached, shrunken, or for any cause unfit for No. 2, and weigh not less than 55 pounds to the measured bushel.

No. 4 Durum Wheat.—Shall include all durum wheat that is badly bleached or for any cause unfit for No. 3, and weigh not less than 50 pounds to the measured bushel.

VELVET CHAFF WHEAT

No. 1 Velvet Chaff Wheat.—Shall be bright, sound and well cleaned, and weigh not less than 58 pounds to the measured bushel.

No. 2 Velvet Chaff Wheat.—Shall be sound, dry, clean, may be slightly bleached, or shrunken, but not good enough for No. 1, and weigh not less than 57 pounds to the measured bushel.

No. 3 Velvet Chaff Wheat.—Shall include all wheat that is bleached, smutty or for any other cause unfit for No. 2, and weigh not less than 55 pounds to the measured bushel.

No. 4 Velvet Chaff Wheat.—Shall include all wheat that is very smutty, badly bleached and grown or for any other cause unfit for No. 3.

PACIFIC COAST WHEAT

No. 1 Pacific Coast Red Wheat.—Shall be dry, sound, clean and free from smut and weigh not less than 59 pounds to the measured bushel.

No. 2 Pacific Coast Red Wheat.—Shall be dry, sound, clean and only slightly tainted with smut and alkali, and weigh not less than 58 pounds to the measured bushel.

No. 3 Pacific Coast Red Wheat.—Shall include all other Pacific Coast red wheat. It may be smutty or musty, or from any other reason unfit for flouring purposes, and weigh not less than 54 pounds to the measured bushel.

Note.—Pacific Coast White Wheat shall be graded according to the rules for Pacific Coast Red Wheat. In case of a mixture of Pacific Coast wheat with our home-grown wheat, red or white, such mixture shall be graded "Pacific Coast Mixed Wheat."

Note.—The grades of Pacific White and Pacific Red Wheat are to include all such wheats as are grown in the extreme Northwest and on the Pacific slope from either spring or winter seeding.

MIXED WHEAT

Mixed Wheat.—In case of an appreciable mixture of hard and soft wheat, red and white wheat (except as provided in the rule of red winter, white winter and northern spring wheat), durum, and spring wheat any of them with each other, it shall be graded according to the quality thereof, and the kind of wheat predominating shall be classed as No. 1, 2, 3 and 4 mixed wheat, and the inspector shall make notation describing its character.

RYE

No. 1 Rye.—Shall be dry, sound, plump, sweet and well cleaned, and shall weigh not less than 57 pounds to the measured bushel.

No. 2 Rye.—Shall be dry, sound and contain not more than 1 per cent of other grain or foreign matter, and weigh not less than 55 pounds to the measured bushel.

No. 3 Rye.—Shall include inferior rye not unsound, but from any other cause not good enough for No. 2, and weigh not less than 53 pounds to the measured bushel.

No. 4 Rye.—May be damp, musty or dirty, and weigh not less than 50 pounds to the measured bushel.

WHITE OATS

No. 1 White Oats.—Shall be white, dry, sweet, sound, bright, clean, free from other grain and weigh not less than 32 pounds to the measured bushel.

No. 2 White Oats.—Shall be 95 per cent white, dry, sweet, shall contain not more than 1 per cent of dirt and 1 per cent of other grain, and weigh not less than 29 pounds to the measured bushel.

Standard White Oats.—Shall be 92 per cent white, dry, sweet, shall not contain more than 2 per cent of dirt and 2 per cent of other grain, and weigh not less than 28 pounds to the measured bushel.

No. 3 White Oats.—Shall be sweet, 90 per cent white, shall not contain more than 3 per cent of dirt and 5 per cent of other grain, and weigh not less than 24 pounds to the measured bushel.

No. 4 White Oats.—Shall be 90 per cent white, may be damp, damaged, musty or very dirty.

Notice.—Yellow oats shall not be graded better than No. 3 white oats.

MIXED OATS

No. 1 Mixed Oats.—Shall be oats of various colors, dry, sweet, sound, bright, clean, free from other grain and weigh not less than 32 pounds to the measured bushel.

No. 2 Mixed Oats.—Shall be oats of various colors, dry, sweet, shall not contain more than 2 per cent of dirt and 2 per cent of other grain, and weigh not less than 28 pounds to the measured bushel.

No. 3 Mixed Oats.—Shall be sweet oats of various colors, shall not contain more than 3 per cent of dirt and 5 per cent of other grain, and weigh not less than 24 pounds to the measured bushel.

No. 4 Mixed Oats.—Shall be oats of various colors, damp, damaged, musty or very dirty.

RED OR RUST PROOF OATS

No. 1 Red Oats or Rust Proof.—Shall be pure, red, sound, bright, sweet, clean and free from other grain, and weigh not less than 32 pounds to the measured bushel.

No. 2 Red Oats or Rust Proof.—Shall be seven-eighths red, sweet, dry, and shall not contain more than 2 per cent dirt or foreign matter, and weigh 30 pounds to the measured bushel.

No. 3 Red Oats or Rust Proof.—Shall be sweet, seven-eighths red, shall not contain more than 5 per cent dirt or foreign matter, and weigh not less than 24 pounds to the measured bushel.

No. 4 Red Oats or Rust Proof.—Shall be seven-eighths red, may be damp, musty or very dirty.

WHITE CLIPPED OATS

No. 1 White Clipped Oats.—Shall be white, clean, dry, sweet, sound, bright, free from other grain, and weigh not less than 35 pounds to the measured bushel.

No. 2 White Clipped Oats.—Shall be 95 per cent white, dry, sweet, shall not contain more than 2 per cent of dirt or foreign matter and weigh not less than 32 pounds to the measured bushel.

No. 3 White Clipped Oats.—Shall be sweet, 90 per cent white, shall not contain more than 5 per cent of dirt or foreign matter, and weigh not less than 30 pounds to the measured bushel.

No. 4 White Clipped Oats.—Shall be 90 per cent white, damp, damaged, musty or dirty, and weigh not less than 30 pounds to the measured bushel.

MIXED CLIPPED OATS

No. 1 Mixed Clipped Oats.—Shall be oats of various colors, dry, sweet, sound, bright, clean, free from other grain, and weigh not less than 35 pounds to the measured bushel.

No. 2 Mixed Clipped Oats.—Shall be oats of various colors, dry, sweet, shall not contain more than 2 per cent of dirt or foreign matter, and weigh not less than 32 pounds to the measured bushel.

No. 3 Mixed Clipped Oats.—Shall be sweet oats of various colors, shall not contain more than 5 per cent of dirt or foreign matter, and weigh not less than 30 pounds to the measured bushel.

No. 4 Mixed Clipped Oats.—Shall be oats of various colors, damp, damaged, musty or dirty, and weigh not less than 30 pounds to the measured bushel.

Note.—Inspectors are authorized when requested by shippers to give weight per bushel instead of grade on Clipped White Oats and Clipped Mixed Oats from private elevators.

PURIFIED OATS

Purified Oats.—All oats that have been chemically treated or purified shall be classed as purified oats, and inspectors shall give the test weight on each car or parcel that may be so inspected.

CORN

Government Grades.—The following grades for corn have been adopted by the United States Government. These grades went into effect July 1, 1914.

Grade classification	MAXIMUM PERCENTAGES OF					
White, Yellow and Mixed Corn	Moisture	Damaged corn			Foreign material including dirt, cob, other grain, finely broken corn, etc.	"Cracked" corn, not including finely broken corn. (See General Rule 9.)
No. 1	14.0	2	Exclusive of heat damaged or mahogany kernels		1	2
2	15.5	4			1	3
3	17.5	6			2	4
4	19.5	8	May include heat damaged or mahogany kernels not to exceed	½ %	2	4
5	21.5	10		1 %	3	5
6	23.5	15		3 %	5	7
"Sample"	See General Rule No. 6 for Sample Grade.					

General Rules.—1. The corn in grades No. 1 to No. 5, inclusive, must be sweet.

2. *White corn*, all grades, shall be at least 98 per cent white.

3. *Yellow corn*, all grades, shall be at least 95 per cent yellow.

4. *Mixed corn*, all grades, shall include corn of various colors not coming within the limits for color as provided for under white or yellow corn.

5. In addition to the various limits indicated, No. 6 corn may be musty, sour, and may also include corn of inferior quality, such as immature and badly blistered.

6. All corn that does not meet the requirements of either of the six numerical grades by reason of an excessive percentage of moisture, damaged kernels, foreign matter or "cracked" corn; or corn that is hot, heat damaged, fire burnt, infested with live weevil, or otherwise of distinctly low quality, shall be classed as sample grade.

7. In No. 6 and sample grade, reasons for so grading shall be stated on the inspector's certificate.

8. Finely broken corn shall include all broken particles of corn that will pass through a perforated metal sieve with round holes nine sixty-fourths of an inch in diameter.

9. "Cracked" corn shall include all coarsely broken pieces of kernels that will pass through a perforated metal sieve with round holes one-quarter of an inch in diameter, except that the finely broken corn as provided for under Rule 8 shall not be considered as "cracked" corn.

10. It is understood that the damaged corn; the foreign material including pieces of cob, dirt, finely broken corn, other grains, etc., and the coarsely broken or "cracked" corn as provided for under the various grades, shall be such as occur naturally in corn when handled under good commercial conditions.

11. Moisture percentages, as provided for in these grade specifications, shall conform to results obtained by the standard method and tester as described in Circular 72, Bureau of Plant Industry, U. S. Department of Agriculture.

MILO MAIZE

No. 1 Milo Maize.—Shall be mixed milo maize of choice quality, sound, dry and well cleaned.

No. 2 Milo Maize.—Shall be mixed milo maize, sound, dry and clean.

No. 3 Milo Maize.—Shall be mixed milo maize, not dry, clean or sound enough for No. 2.

No. 4 Milo Maize.—Shall include all mixed milo maize that is badly damaged, damp, musty or very dirty.

Milo maize that is wet or in heating condition shall not be graded.

KAFFIR CORN

No. 1 White Kaffir Corn.—Shall be pure white of choice quality, sound, dry and well cleaned.

No. 2 White Kaffir Corn.—Shall be seven-eighths white, sound, dry and clean.

No. 3 White Kaffir Corn.—Shall be seven-eighths white, not dry, clean or sound enough for No. 2.

No. 4 White Kaffir Corn.—Shall be seven-eighths white that is badly damaged, damp, musty or very dirty.

No. 1 Red Kaffir Corn.—Shall be pure red corn, of choice quality, sound, dry and well cleaned.

No. 2 Red Kaffir Corn.—Shall be seven-eighths red, sound, dry and clean.

No. 3 Red Kaffir Corn.—Shall be seven-eighths red, not dry, clean or sound enough for No. 2.

No. 4 Red Kaffir Corn.—Shall be seven-eighths red that is badly damaged, damp, musty or very dirty.

No. 1 Kaffir Corn.—Shall be mixed kaffir corn of choice quality, sound, dry and well cleaned.

No. 2 Kaffir Corn.—Shall be mixed kaffir corn, sound, dry and clean.

No. 3 Kaffir Corn.—Shall be mixed kaffir corn, not dry, clean or sound enough for No. 2.

No. 4 Kaffir Corn.—Shall include all mixed kaffir corn that is badly damaged, damp, musty or very dirty.

Kaffir corn that is wet or in heating condition shall not be graded.

BARLEY

(These Barley Rules have been adopted by the Barley Association of the United States.)

No. 1 Barley.—Shall be sound, plump, bright, clean and free from other grain, and not scoured or clipped, shall weigh not less than 48 pounds to the measured bushel.

No. 2 Barley.—Shall be sound, of healthy color (bright or straw color), reasonably clean and reasonably free from other grains and seeds, and not scoured nor clipped, shall weigh not less than 46 pounds to the measured bushel.

No. 3 Barley.—Shall include slightly shrunken or otherwise lightly damaged barley, not good enough for No. 2, and not scoured nor clipped, shall weigh not less than 44 pounds to the measured bushel.

No. 4 Barley.—Shall include barley fit for malting purposes, not good enough for No. 3.

No. 1 Feed Barley.—Shall test not less than 40 pounds to the measured bushel, shall be cool and reasonably free from other grain and seeds, and not good enough for No. 4, and may include barley with a strong ground smell, or a slightly musty or bin smell.

Rejected Barley.—Shall include all barley testing under 40 pounds to the measured bushel, or barley which is badly musty or badly damaged, and not good enough to grade "feed" barley, except that barley which has been chemically treated shall not be graded at all.

Bay Brewing Barley.—The grades of Nos. 1, 2 and 3 Bay Brewing barley shall conform in all respects to the grades of Nos. 1, 2 and 3 barley, except that they shall be of the Bay Brewing variety, grown in the far West and on the Pacific Coast.

Chevalier Barley.—The grades of Nos. 1, 2 and 3 Chevalier barley shall conform in all respects to the grades of Nos. 1, 2 and 3 barley, except that they shall be of the Chevalier variety, grown in the far West and on the Pacific Coast.

Bay Brewing Mixed Barley.—In case of admixture of Bay Brewing barley with barley of other varieties, it shall be graded according to the quality thereof and classed as 1, 2, 3 Bay Brewing Mixed Barley.

Chevalier Mixed Barley.—In case of admixture of Chevalier barley with barley of other varieties, it shall be graded according to the quality thereof and classed as 1, 2, 3 Chevalier Mixed Barley.

WINTER BARLEY

No. 1 Winter Barley.—Shall be plump, bright, sound and clean, free from other grain, and weigh not less than 48 pounds to the measured bushel.

No. 2 Winter Barley.—Shall be sound, plump, may be stained, shall contain not more than 3 per cent of foreign matter, and weigh not less than 46 pounds to the measured bushel.

No. 3 Winter Barley.—Shall include all shrunken, stained and dirty barley, shall contain not more than 5 per cent of foreign matter, and weigh not less than 44 pounds to the measured bushel.

No. 4 Winter Barley.—Shall include all barley not fit for a higher grade in consequence of being poor quality, damp, musty or dirty; shall contain not more than 10 per cent of foreign matter and weigh not less than 40 pounds to the measured bushel.

SAMPLE GRADES—GENERAL RULE

All wheat, barley, oats, rye and corn that is in a heated condition, souring, or too damp to be safe for warehousing, or that is badly bin-burnt, fire-burnt, fire-smoked, or badly damaged, mixed with garlic, onions, or containing live weevil, exceedingly dirty, or where different kinds of grain are badly mixed with one another, shall be classed as Sample Grade, and the inspector shall make notations as to quality and condition.

Notice.—The inspection departments shall in no case make a grade of grain above that of the poorest quality found in any lot of grain inspected, when it has evidently been plugged for the purpose of deception, or otherwise improperly loaded. Wheat which has been subjected to scouring, or clipping, or any process equivalent thereto, shall not be graded higher than a 3.

New.—The word "NEW" shall be inserted in each certificate of inspection of a newly harvested crop of oats until the fifteenth day of August; of rye, until the first day of September; of wheat, until the first day of November, and of barley, until the first day of November of each year.

This change shall be construed as establishing new grades for the times specified, to conform to the existing grades of grain in all particulars, except the distinctions hereby established between the new and the old crop, and shall apply to grain inspected from store for two months after the time respectively above specified.

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